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The role of bioscience and biotechnology in agricultural education in the secondary school agriculture curriculum as perceived by agricultural educators

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The role of bioscience and biotechnology in agricultural education in the secondary school agriculture curriculum as perceived by agricultural educators

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Signature was redacted for privacy.

Major Professor

Signature was redacted for privacy.

For the Major Program

DEDICATION

For my children Connie and Luke and for my late parents

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ABSTRACT

The purpose of this study was to identify perceptions of agriculture teachers regarding the role of biosciences/ biotechnology in the study of agriculture in the North Central Region of the United States. The study sought to determine the degree to which teachers perceived the importance of infusing biosciences/biotechnology into the agriculture curriculum. Another objective of the study was to determine the extent to which competencies in biosciences/biotechnology could be taught if additional instructional materials and inservice training were provided to the teachers.

This was a survey research study, conducted with a stratified random sample of 610 individuals selected from the 2,429 secondary school teachers in the North Central Region of the United States. The findings were based on 325 completed questionnaires. Non-response error was controlled enabling findings to be generalized to the general population of agricultural educators in the North Central Region.

Findings indicated that secondary school educators in the North Central Region of the United States were mainly middle-aged and predominantly male. The instructors had favorable perceptions about the role of biosciences/ biotechnology in the agriculture curriculum. Their perceptions did not vary with their demographic characteristics. The instructors believed that by integrating the sciences into their curriculum they would prepare their students better for future employment opportunities in science and technology particularly in the area of biotechnology, which is a rapidly expanding industry.

Instructors were more willing to expand instruction in areas of competencies related to traditional ways of increasing plant growth and production. The instructors were also willing to expand instruction in the areas of competencies for sustainable agriculture,

environmental education and animal science. They were less willing to expand instruction in areas of competency that were related to cell biology from which major developments in biotechnology arise.

Slightly over a half of the instructors had attended preservice training in biotechnology. The findings of this study indicate that nearly a half of the instructors had no training in biotechnology as beginning teachers. Slightly over three fifths of the instructors had attended some type of inservice education in biotechnology. This finding was surprising as several of the instructors indicated that they needed more inservice for them to feel more confident to integrate more science into the agriculture curriculum.

Many instructors were interested in integrating more bioscience/ biotechnology into their programs but many believed there were barriers preventing them to do so. The instructors believed that they needed appropriate additional instructional materials and inservice training. The educators also believed that integrating the sciences into their curriculum would require more time, facilities, and equipment.

CHAPTER I.
INTRODUCTION

A sustainable system of crop production is one that is able to maintain a balance between production and conservation of natural resources for several years. This system's production is based on the potential and limitations of a particular region; it does not exert adverse pressure on the environment, but makes the best use of energy and materials and benefits the health and wealth of the local population at competitive costs (Wood, 1996).

In agriculture, at least in the U.S.A., the1970s were looked upon as the decade for prosperity and expansion of the use of the land, to increase production to provide food for the growing world population (Hulse, 1995). However, the 1980s were a time of recession whereby farmers sought to increase production to maximize utilization of the land by increasing their inputs. The prosperity of the 1970s which resulted in the intensification of inputs to maximize economic benefits of agriculture could not be viable with the increasing human population (Daley, 1996). This increase in population meant that humans no longer had unlimited natural resources to meet their desires and unlimited places for wastes generated by their activities (Kirschenmann, 2000). Thus, the 1990s became a decade of increasing awareness of environmental degradation as a result of conventional farming practices. Hence, a new vision for agricultural production in the 1990s was to optimize production but at the same time conserve the environment (Barrick, 1989).

Some farmers are turning to sustainable agriculture both for economic and environmental reasons. Research conducted by the American Farmland Trust showed several farmers around the country were relying on practices that implied sustainable agriculture (Farmland Trust, 1989). Research by Lasley, a rural sociologist at Iowa State University, indicated similar farming patterns in Iowa (Pins, 1990).

Some people in industry and at the universities believe that the future of sustainable agriculture is tied to the development of new technologies. Advanced research and technology development in crop production has made it possible to maximize production. This new technology could be used to maintain or increase production by using techniques that protect the environment. Fehr (1989) contended that biotechnology and sustainable agriculture need each other, they cannot work independently. If sustainable agriculture and biotechnology work independently, the alternative management systems will not benefit through the application of knowledge in the biological sciences (Fehr, 1989). Leading industry personnel, of the Monsanto Technology division, believed that bioengineering could produce plants tolerant to high salt soils, resistant to heat, cold, diseases, pests and drought and/or have increased nutritional content, lower saturated fats and better taste (Ferguson, 1990). People in the industry believe that the three greatest obstacles to commercial development of biotechnology products are public ignorance, suspicion, and fear.

Agricultural education can play a major role in educating the public in changing perceptions about biotechnology (Ferguson, 1990). Some people believe that there should be an equal emphasis on technology development, and education in biotechnology and sustainable agriculture for people to accept these changes. Doubleday (1996) was optimistic about biotechnology giving advantages to both producers and consumers. For producers, biotechnology could mean a reduction in unit costs of production that would translate to advantages to consumers in lower cost of produce.

The U.S.A. food and agricultural system is based on two vital components: natural resources and science and technology (Stanbury and Coulter, 1986). The natural resource base has limited capacity to sustain continued expansion of the agricultural industry (Bentley, 1986). However, it is believed that most people in the US take their relationship with the environment for granted and do not stop to think that it may not always be able to sustain all the activities if it is badly degraded (Orr, 1992).

National and state policies have been mandated for the continued protection of soil and water indicating a need for an expanded conservation education initiative. Leopold (1960) believed that the natural resources were to be loved and respected not only as an extension of ethics, but as a necessity to human survival. However, until very recently the relationship between the people and the natural resources in the industrial society has been economic, stressing the privileges and not the obligations. Leopold (1960) believed that people must become more aware of their obligations to protect the environment before sustainable agriculture can become a reality.

Therefore, using emerging technologies such as biotechnology to improve and maintain agricultural productivity while conserving natural resources has great potential in agriculture (Gardener, 2000). Although natural resource education is becoming increasingly important (Bentley, 1986), there is still a need to educate the general public and consumers on the potential of these technologies.

Competition for agriculturally potential land for non-agriculture uses such as recreation, industrial and residential needs makes it necessary to have changes in land and water use. Therefore, current and future agricultural workers must have the ability to properly manage and conserve natural resources (Dik, 1986). Krantz (2000) noted that some leaders in Iowa were of the opinion that biotechnology would help feed the world as farmland disappears.

Loomis (1986) contended that agricultural education had a major role to play in providing education related to the mix of new technology related to natural resource conservation. A national study in agricultural education conducted by the National Academy of Science supported this view by recommending that new curricula be developed and made available to teachers, addressing sciences basic to agriculture, food, and natural resources (Committee on Agricultural Education in Secondary Schools, 1988).

Environmental management using the technical approach is useful to address the immediate environmental degradation issues, but the long-term effects can only be achieved through education (Rolings and Wagemaker, 1998). Since environmental mismanagement is a result of human activity, a change in behavior can only be achieved through education. Environmental education within the school system has been seen by many as a "science of survival" or social values change and a common sense "need to know" subject for everyone (Allison and Carrington, 1980). Allison and Carrington (1980) believed that educators throughout the country were beginning to address the environmental problems.

The current environmental concerns and legislation related to natural resources and public skepticism about new technologies justifies the need to expand agricultural education on these new technologies and environmental issues. One result of the last national reform of the old traditional vocational agriculture program in the 1980s has been the emergence of a more flexible curriculum in agriculture. There was a great need to reform secondary school agriculture programs and curricula to expose students to a wider selection of careers in agriculture. It was important that the curricula also instill higher environmental consciousness and challenge students with emphasis on contemporary agricultural science and technologies such as biotechnology.

Statement of the Problem

Conventional methods of crop production and crop protection rely heavily on chemicals and machinery, major contributors to environmental degradation. These conventional methods also rely heavily on fossil fuels that deplete the limited natural resources (Gliessman, 1998). Dekker (1991) estimates the global expansion in pesticide sales between 1960-1989 to have increased by 100% with the U.S. leading in the use of herbicides estimated at $3.4 billion (B), Western Europe in fungicide use estimated at $2.1B, and the Far East in insecticides at $2.3B. The use of fungicides is increasing rapidly because the present knowledge of plant pathogens makes it difficult to control them without resorting to fungicides (Hulse, 1995).

Hulse (1995) was of the opinion that biotechnology had a great potential to produce more viable options to ensure plant health, and improve or maintain agricultural productivity compared to other non-chemical alternatives consistent to sustainable agriculture. It is estimated that crop loss through pests and diseases is about 30%, so even if using chemicals to protect the plants is reduced, the alternative must be effective enough to reduce these losses (Hulse, 1995).

However, a large section of the public does not understand the benefits of biotechnology to agriculture, especially in improving agricultural productivity (Marshall, 1996). Extensive use of biotechnology to improve crop protection and production for sustainable agriculture is hindered by the general public's lack of knowledge on the usefulness of the new technologies combined with cultural methods to improve agricultural productivity (Marshall, 1996). The National Agricultural Biotechnology Council (NABC) has sponsored annual conferences to educate the public dealing with a wide range of topics especially topics on the environment, food safety, and animal and crop applications of biotechnology (Marshall, 1996). The NABC's committee on education is attempting to develop a list of publications that would be useful for public education (Marshall, 1996). The public needs to be educated so they can make informed choices; without information, choice has no value (Hatch, 1996). Trexler (2000) contended that individuals need to have a basic understanding of scientific and technological principles to assess the benefits of pesticides and Genetically Modified Organisms (GMO's) in terms of human health and environmental safety.

Biotechnology has undoubtedly changed and will continue to transform agriculture, but not all of its effects are positive. Critics of biotechnology contend that government regulatory bodies such as the Food and Drug Administration (FDA) and the Environmental

Protection Agency (EPA) have been overly optimistic about biotechnology when some caution is necessary to protect the consumers (Lappe and Bailey 1998). Europe, which could be a potential market for American biotechnology products, has an inherent distrust of American regulatory agencies such as FDA and EPA, because they have given a "clean bill of health to many products and chemicals that have later proven harmful (Lappe and Bailey, 1998). Hamilton (2000) noted at a Biotechnology Symposium held in Des Moines, Iowa, that scientists and officials were determined to forge ahead with the technology despite growing resistance in many developed nations. According to Hamilton (2000), proponents of biotechnology drowned alternative views to this technology at this symposium because they held the higher ground. Biotechnology is seen as a technology that may threaten rural economies because creation of non-farm employment in the rural structure has been minimal (Schor, 1994). Women in the European market have some resistance to this technology because they see the American chemically based transgenic agriculture as a male dominated operation (Lappe and Bailey, 1998)

Although the media and NABC's efforts to educate the public can help in alleviating the public's fear and suspicion of these modern technologies, an easier method would be to educate the young people on the potential of biotechnology. According to Marshall (1996), NABC has also targeted education efforts to young people and has suggested incorporating biotechnology into 4-H manuals and projects. Collaborative youth education efforts among states are also encouraged by NABC in order for the different states to learn from each other's experiences to minimize duplication of effort (Marshall, 1996).

Tyler (1950) contended that if a curriculum is used with the group as it was intended, the desired objectives of the curriculum should be achieved. The teacher's beliefs as well may have an impact on student learning. Some researchers are of the opinion that teachers' beliefs have an effect on student learning (Orton, 1996). Modern agriculture has a more technological base compared to the traditional agriculture. Critics of the agricultural education curriculum contend that it was still focused on production agriculture yet the needs of the students in the agriculture programs and the industries that would employ the students had changed. The curriculum in agricultural education at the secondary school was in need for change in order to meet the needs of the students and to prepare the students better to work in a modern agricultural industry

Rajasekeran (1989) conducted a national study to determine the role of bioscience/ biotechnology in agricultural education as perceived by secondary school agricultural educators. This study found that the agricultural educators who participated were of the opinion that biotechnology was and would remain a powerful presence in agriculture. The study also found that most of the teachers, who were not willing to accept the changes, feared they would not be able to keep up with the changes because of a lack of appropriate instructional materials, a lack of funds, conflict with science departments, and lack of encouragement from administrators. Even teachers with negative views recognized biotechnology as a wave of the future and believed that if the agriculture curriculum did not incorporate the biosciences, it would not be relevant to most of their clientele. Twelve years after conducting the Rajasekeran study, it is clear that we need to ask teachers once again about the extent to which they should be infusing bioscience / biotechnology into the curriculum.

The current study assessed teacher's perceptions regarding the role of bioscience/ biotechnology in agricultural education in the North Central Region. This study was conducted 12 years after the reform of the curriculum in agriculture in secondary schools was started. This reform movement recommended infusion of more science into the agricultural education curriculum. After 12 years one would expect that the agriculture instructors and the public should be more aware of biotechnology and its role in agriculture. One would also expect that teachers would be more willing to infuse more bioscience/ biotechnology into the agriculture curriculum. The problem that this study was concerned with was to identify the teachers' perceptions regarding the role of bioscience/ biotechnology in the agricultural education curriculum at the secondary school level as a means of assessing their willingness to integrate more bioscience into the curriculum.

Purpose of the Study

The purpose of this study was to identify the role of bioscience and biotechnology in the agricultural education curriculum as perceived by teachers in the North Central Region of the USA. This study sought to determine the degree to which teachers perceive competencies in bioscience/ biotechnology could be infused into the agriculture curriculum. Some teachers have received related teaching materials to help them teach biotechnology in agriculture. How willing are teachers to expand instruction in agriculture if provided additional materials and inservice training? The study sought to describe the development of an appropriate inservice program for the teachers that would encourage them to integrate the biosciences into the agricultural education curriculum. The results of this investigation will be useful to agricultural educators throughout the United States who would like to develop more linkages with industry to emphasize the application of science and others concerned with developing instructional materials to incorporate biotechnology into the study of agriculture.

The specific objectives of the study were to:

1. identify the perceptions of secondary school agricultural educators regarding the infusion of biotechnology into the agricultural education curriculum in the North Central Region of the U.S.A.,
2. identify the extent to which selected competencies appropriate to biotechnology should be infused into the Agricultural Education curriculum,
3. determine the degree to which education on biotechnology would be taught if inservice education and instructional materials on biotechnology in agriculture were provided to the teachers, and

4. compare respondents' perceptions using selected demographic factors.

Need for the Study

The reform of the curriculum for agriculture in secondary schools in Iowa began in 1989. as a result of recommendations from the Iowa Technical Committee on Biotechnology (1987). This committee recommended infusion of more basic sciences into the agricultural education curriculum at the high school level. It was recommended that the infusion of more science into the agriculture curriculum would provide a basic foundation for the students in the principles and concepts of biological sciences necessary for understanding agricultural biotechnology during their undergraduate and graduate education.

The Iowa Technical Committee on Biotechnology further developed an inventory of biological science competencies appropriate for the agriculture curriculum. The Committee on Agricultural Education in Secondary Schools established by the National Research Council made similar recommendations identified by the Iowa Technical Committee on Biotechnology for infusing more science courses into the agricultural curriculum (Committee on Agricultural Education, 1988). This view was further strengthened by the NABC (1997) that contended that the challenges to agriculture could only be more effectively answered by new innovations in biotechnology (Knight et.al., 1997).

Nearly twelve years after these recommendations were made; there is still a great deal of mystery and myth in the public surrounding biotechnology and agriculture. Certain sectors of the public are more aware of the use of biotechnology in advancing agricultural production and others are still ignorant of the impact of this technology on agriculture (Lappe and Bailey, 1998). The NABC also contended that education of the general public about the unique contributions of agriculture to the U.S. economy and to the quality of life of all Americans is important so that the average person can understand why she/ he needs to continue to support agricultural research institutions (Marshall, 1996). Krantz (2000) contended that leaders in Iowa believed that there is a need for the Iowa Biotechnology

Association to educate the public on the importance of this science. The current debate on the usefulness of biotechnology as a means to improve agricultural productivity provides a basis for this study.

Although the agriculture curricula is in the process of being transformed, do teachers perceive this focus on bioscience/ biotechnology as an important change or necessary to the agricultural curriculum? Do teachers have sufficient and / or appropriate resource materials to help them teach biotechnology in agriculture. Do agriculture teachers think that infusing more biotechnological aspects into their courses will be beneficial to students?

Definition of Terms

Ary, Jacob and Razavieh (1996) state that in any particular study to ensure that everyone understands the context in which a particular term is used; operational definitions should be provided to delimit the meanings of the terms. The following terms were defined to help frame and clarify major components of the study.

Agricultural education: The study of agriculture at the secondary school level.

Agricultural education instructor: The educator responsible for teaching and conducting an agricultural education program at the secondary school level.

Bioscience: A systematic study of the principles and concepts applied to the functions and problems of living organisms.

Biotechnology: Any techniques, which use living organisms, parts of living organisms or their products for commercial purposes (Bio I, 1993)

Competencies: The specific knowledge and skills in sciences basic to biotechnology perceived to be important by agricultural educators in secondary schools.

Descriptive survey research: Studies that seek to establish relationships or distribution of variables through descriptive questions but do not involve manipulation of variables (Ary, Jacob and Razavieh, 1996).

Inservice education: Education provided for someone already in employment.

Instructional materials: Materials used to enhance the instructional process.

Perceptions: What a person believes to be true at a given point in time.

Preservice Education: Education provided for someone still in training.

Sustainable Agriculture: Application of agricultural technologies or practices in farming that are ecologically sound, environmentally humane, economically viable, and socially responsible.

Teaching: Teaching is the process by which a person facilitates the learning process.

CHAPTER II

REVIEW OF LITERATURE

Introduction

The purpose of this study was to identify perceptions of agriculture teachers regarding the importance of biotechnology in the study of agriculture in the North Central Region of the United States. The study sought to determine the degree to which teachers perceive the importance of infusion of bioscience into the agricultural education curriculum. Another objective of the study was to determine the extent to which competencies in biotechnology could be taught if inservice training in biotechnology and additional instructional materials were provided for the teachers. Selected demographic factors were used to compare teachers' perceptions in this study.

The theoretical framework for this study was based on the social reconstructionist theory of curriculum development. Social reconstructionists are interested in the relevance of the curriculum to the social, political, and economic development of the society. Brameld (1956) outlined the distinctive features of social reconstructionism. He believed that 1) there was an urgent need to build a new culture and a need for the common people to control the fiscal, cultural and natural resources. 2) He also believed that the working people should control all the principle institutions and resources if the world was to be truly democratic. 3) Brameld further contended that the schools should help the students not only to develop socially but also to learn how to participate in social planning.

The primary purpose of the social reconstructionist curriculum is to confront the learner with the many severe problems that society faces. According to McNeil (1996) these problems are not the exclusive concerns of "social studies" but of every discipline. Optimistic social reconstructionists are convinced that education can effect social change; for example a curriculum aimed at raising consciousness about environmental concerns. Pessimists on the other hand doubt the ability of the curriculum to change the existing social attitudes and behavior. However both optimists and pessimists want curriculum that challenges creative thought and encourages learners to look at alternate ways of accomplishing missions. They want learners to understand how the curriculum is used to define society (McNeil. 1985).

It was the intent of this study to assess the perceptions of the agricultural educators regarding the role of bioscience/ biotechnology in the secondary school agricultural education curriculum and to determine their willingness to integrate more bioscience into their curriculum given additional instructional materials and inservice training.

An extensive literature review was conducted on curriculum development. the significance of biotechnology to modern agriculture, and how the basic sciences are important in the utilization of biotechnology. Twelve years after the secondary school agriculture curriculum was recommended to be reformed very little research has been done to determine the extent to which biotechnology is being taught in the agricultural education curriculum. There is very little information available on the extent to which science is being infused into the agricultural education curriculum.

Curriculum Development

The underlying philosophy for changing the curriculum contains some elements of the rational model of Tyler (1950). The Iowa Technical Committee on Biotechnology (1987) recognized that the growing presence of biotechnology in the agricultural industry would need students to be prepared with a greater basic science foundation.

The need to reform the existing agriculture curriculum by the National Research Council (Committee on Agricultural Education, 1988) came about in the wake of calls to integrate more basic science and mathematics into practical teaching learning situations to improve student learning. The National Research Council (Committee on Agricultural

Education, 1988) also stated that there was a need to reform the agriculture curriculum to cater to the changing needs of the clientele in agricultural education.

Policymakers, educators, employers, scholars and social critics advocated for vocational education reform that dealt with integration of more science into the curriculum (Stasz, Kaganoff, and Eden, 1994). Integration of sciences basic to agriculture was seen by some critics of vocational education programs like agriculture as necessary to improve academic content of these programs and to help prepare students for employment in the ever-changing work world (Stasz and Grubb, 1991; O'Neil, 1992).

Blum (1996) was of the opinion that agriculture can contribute to science education but science is absolutely essential for understanding modern agricultural practices and applying such to benefit farmers. Therefore, science education has an important role in the agriculture curriculum.

Science as a Foundation for Biotechnology

The biosciences provide the basic foundation for biotechnology. Mayer and McInervey (1984) contended that the basic knowledge of the sciences, particularly of genetics and microbiology, was needed to understand and effectively apply the concepts of biotechnology. It is from the knowledge of genetics that one learns about manipulating genes in plants and animals to produce varieties and breeds that are disease resistant and drought, and heat tolerant so that they can grow in environments that were previously not conducive for their growth.

The study of microbiology can also be used to help students understand the concepts by using simple organisms such as *Escherichia. coli* with little expense and equipment available in secondary school laboratories (Mayer and McInervey, 1984). Microbiology, using the age-old technology of fermentation, can also help students understand why this process is essential in food processing industries and post-harvest technology (Harlander and

Garner 1986). The tools of biotechnology built on the base of understanding derived from sciences such genetics. microbiology, and biochemistry, complement the traditional methods of agricultural production (Hess, 1987).

Kam (1984) believed that students need a strong foundation in the sciences basic to biotechnology, not only for preparing them for broader careers in the field of biotechnology, but also to enhance the application of this new technology in practical agriculture. McCormick and Cox (1988) considered an education that only emphasized specific facts of agribusiness and renewable natural resources, without integrating the 'why' and 'know- how' aspects of the basic sciences, inadequate. The National Academy of Sciences (1985) considered basic knowledge of the biology of microorganisms such growth and metabolism of viruses, bacteria, and fungi essential for identifying naturally occurring control agents.

According to Buriak (1989), the National Science Board, a commission for pre-college education in mathematics, science, and technology, believed that basic science instruction is necessary to stimulate students to formulate their own research questions in observing and interpreting natural phenomena. This type of education would also enhance the students' problem-solving and critical thinking skills in all areas of learning.

Science-based learning will also encourage students to develop innovative and creative thinking skills, which could prepare them for diverse science and technology- related careers open to students with varying aptitudes and interests. A science-based curriculum will also stimulate interest and provide basic academic knowledge necessary for advanced study by students interested in pursuing science professionally (Buriak, 1989). Rao and Pritchard (1984) further contended that using basic sciences, as the basis of agriculture education programs, would stimulate students to learn science as it is practiced in the real world.

Needs Assessment

The curriculum for agricultural education should be planned within the context of the needs of agricultural education as a discipline and the projected needs for human resources in agriculture (Blum, 1996). Conducting a "needs assessment" regarding the future needs for agricultural education is not easy. More and more agricultural education graduates are finding employment in agriculturally related areas that are not in production agriculture. especially in the expanding agricultural biotechnology industry.

In 1989, when the reform of the agriculture curriculum in secondary schools was started, most people believed that the curriculum had lagged behind the agricultural industry. The agriculture curriculum was a typical example of what Rugg (McNeil, 1996) considered a lazy giant, remaining focused in the past when the signs of the times clearly indicated that things had changed. According to the Committee on Agricultural Education in Secondary Schools (1988) even the student organizations such as "the Future Farmers of America (FFA) and Supervised Occupational Educational programs (SOE)" were not meeting the broader needs for agricultural education programs. The committee believed that the SOE and FFA programs did not reflect the broad range of opportunities that were available in the agricultural industry.

The Iowa Technical Committee on Biotechnology (1987) created the awareness of the need for the infusion of the basic sciences into the agriculture programs to improve students understanding of the basic biological functions of plants and animals. An understanding of these basic concepts would direct the students' attention to the need to improve traditional technologies for processing and utilizing agricultural products. This knowledge would also enable students to utilize career opportunities in agriculture that are business-oriented (Martin, 1987). Moore (1987) was also of the opinion that students having the knowledge of the basic biological functions of plants and animals would understand how interconnected living things are, as a part of the same cycle of matter and energy. In the midst of the national reform of the agriculture curriculum, what are the perceptions of teachers regarding the infusion of the bioscience /biotechnology into the curriculum?

Malpiedi (1989) was of the opinion that need for the infusion of science into the agriculture program was reinforced by three movements: (1) the back to the basics emphasis of mathematics and science, (2) the National Study on Agricultural Education in the United States which stated that the subject matter about agriculture needed to be broader, and (3) the rapid pace by which agriculture was changing. All of the factors made it necessary for agriculture education programs to accommodate major changes. Malpiedi (1989) further contended that efforts to emphasize science concepts and applications in agriculture education went unheeded because most of the agriculture programs had been so watered down; they had very little science application in them.

The National Commission on Pre-college Education (1983) reported a need for curricula that utilized science in agriculture in practical situations to improve student learning and stimulate student interest. Forte (1989) advocated the need for the agriculture curriculum to focus on scientific principles of agriculture not only for the benefit of the students but also to increase the awareness of parents, administrators, counselors, and other teachers not involved in the science of agriculture.

Blum (1996) was of the opinion that the use of the school gardens for the agriculture curriculum would provide the teachers with the unique opportunity to set up meaningful experiments based on sound scientific experimental procedures in which the results could be of high practical significance. The school gardens could be used to practically apply biological principles and could help in the transfer of learning. This was especially true in situations where agriculture and science were combined into one subject (agriscience); the school garden could be useful in helping students understand modern agricultural practices and applying them to benefit producers.

The Role of Biotechnology in Developing Career Opportunities

Biotechnology has transformed both the agricultural production system and the agricultural research system, by creating a technical base that can be shared by the pharmaceutical, agricultural, chemical, and food processing industries (Schor, 1994). In the same way, biotechnology promises to change the employment base of the agricultural industries.

Stansbury and Coulter (1986) contended that although farming and ranching were the most visible parts of the food and agriculture system, they only account for one-sixth of the employment opportunities in the agriculture sector amounting to one fifth the national employment. Science and technology have a greater potential for creating more job opportunities. Harris (1989) saw many employment opportunities becoming available within the fields of biotechnology and communication.

Although animal biotechnology offers great opportunities, plant biotechnology has the greatest potential (Schor, 1994). According to Schor (1994), plant biotechnology offers the greatest potential because the "seed" which is the medium containing vital genetic information, is of primary importance to biotechnological research. So phenomenal is the transformation of agriculture by biotechnology, that leading chemical companies are focusing their attention to biotechnology with their main enterprise of producing chemicals receiving less attention (Lappe and Bailey 1998).

This change in focus by renowned chemical firms has caused the American Chemical Society (1997) to wonder who will make chemicals if all firms are conducting research and developing biotechnology products. If biotechnology can cause a transformation in production and industrial agriculture in established chemical firms, shouldn't agricultural educators aware of these changes, prepare their students for employment in these new emerging technologies?

Employment opportunities in biotechnology in agriculture are not limited to technology that influences production agriculture only. There are also more opportunities available in food processing as a result of this biorevolution (Schor, 1994). Genetically engineered microbes can be used in the conversion of wastes of low value products into those of higher value.

According to Schor (1994), the only foreseeable limitation to the modern biotechnology development in the agricultural industries is scarcity of skilled manpower. Schor (1994) contended that the shortage of skilled labor is sufficiently acute that American firms have had to recruit qualified non-citizens for these positions. Therefore, the state of the agricultural industry in the U.S. requires that the students be well grounded in the sciences basic to biotechnology to make use of these increasing career opportunities in the biotechnology industry.

The House Committee on Agriculture (1984), in its paper on "The long-term Policy to Succeed the Agriculture and Food Act of 1981" recognized the potential for diverse career opportunities in the field of agricultural science and technology. This committee recommended that a "needs assessment of the food and agricultural sciences" human resources be conducted to ensure the supply of human capital. The house committee also believed that new federal initiatives were required to stimulate teaching programs in agriculture, using state-of-the-art approaches to curriculum innovations.

The House Committee on Agriculture (1984) also alluded to the fact that the United States' food and agricultural system is seriously threatened by a shortage of skilled man-power such as highly qualified scientists, managers, and technical professionals. The committee was of the opinion there was an insufficient number of highly capable students interested in advanced degree programs in the basic agricultural sciences and technical specialties to meet the nations' need for food and agricultural science expertise.

The United States Department of Agriculture (USDA) had a program for higher education that had several initiatives to ensure the training and the supply of well-educated and trained scientists (House Committee on Agriculture, 1984). These initiatives included co-sponsorship of a project by the Council for Agricultural Science and Technology (CAST) to enhance the high school science teachers understanding of the agricultural research systems' missions. CAST also publishes periodic publications on selected agricultural science topics such as water quality, food safety, and plant molecular genetics directed to high school science teachers. The second initiative was student recruitment strategies. This project was two-fold, (i) seeking to enhance the image of agricultural careers among graduates from urban and suburban high schools, and (ii) to increase the enrollment of these students as well as students from high school vocational agricultural programs. This initiative is significant in that students in the vocational agriculture programs have also been considered for future careers in the areas of agriculture science and technology. The USDA and USDE have shown their commitment to improving the agricultural education in secondary schools by jointly sponsoring a study by the National Academy of Sciences to improve the level of technology and how it can be effectively used to teach agriculture in secondary schools (House Committee on Agriculture, 1996)

The USDA recently launched a competitive grants program designed to strengthen agricultural education with the intention of preparing more students to pursue careers in agriscience and agribusiness by incorporating agriscience into science, business and consumer education programs (Balschweid and Thompson, 1999). These initiatives by the U.S.D.A. further confirm the recommendations made by several advisory boards of the need to reform the agriculture curriculum.

O'Kelley (1985) was of the opinion that vocational agriculture instruction can and should contribute to career education at the secondary school level. However, since major increases in job opportunities are in agrisciences, the students need to have a strong foundation in the basic science of agriculture. According to Duval (1988), students need to prepare for career opportunities that extend beyond production agriculture within their local communities.

Schor (1994) contended that although the biotechnology industries in agriculture have done very little to boost the rural economy, most of the firms manufacturing the products are located in rural areas and hence will provide employment in non-farm areas for future agriculture graduates. Vold (1988) also contended that the primary motive of vocational agriculture instructors was to prepare the young people for future job opportunities; therefore, modifying the curriculum to achieve this goal would be the obvious thing to do to continue this proud tradition.

Meeting the Needs of Agriculture Students

Duval (1988) contended that some educational research indicates that infusion of biotechnology into the agriculture curriculum is not only important in the preparation of students for diversified occupations but can also play a significant role in meeting the special needs of some students. Duval (1988) was of the opinion that the integration of science into the agriculture curriculum made it interesting. He gave an example of how this was a key factor in motivating students in the department of agricultural education in Boonville, California, who were previously unmotivated and disinterested in their education.

In California, the "Farming Agriculture and Resource Management for Sustainability" (FARMS) program, created in 1993, successfully educated urban, suburban, and rural youth about the connection between sustainable agriculture, science, and natural resource conservation (Kimball, 2000). The FARMS program has been successful because, in addition to exposing the students to the family farm way of life, FARMS presents agriculture as a career choice to students and demonstrates the science behind agriculture in each of their workshops (Kimball, 2000). The FARMS project makes the integration of science into agriculture feasible through practice.

Perry (1989) was of the opinion that integrating science into agriculture, especially in the Supervised Agricultural Experience (SAE) programs could serve to motivate students from low-income groups and students who were potential school dropouts. For instance, students could help plan their own experience. This experience would be beneficial if it involved an enterprise of value they could sell at the local market and derive some income (Perry, 1989).

Mckay (1988) believed that agriscience meets the needs of the students, especially in the development of their individual agriscience projects. The students had a sense of ownership of these projects; they became actively involved in their learning and discovered the purpose of being in school.

Vold (1988), on the other hand, believed that integrating science into agriculture would be a disadvantage to the underachievers who were normally directed to vocational agriculture programs. He considered these students not the kind who would appreciate biotechnology. Caine and Caine (1991) would disagree with this view because in their studies based on neural studies of the human brain they contend that any healthy human being has the capacity to learn anything provided they can make connections that are meaningful to them and can help them learn the content of unfamiliar subject matter. However, Vold (1988) also believed that introducing biotechnology into the agriculture curriculum at the high school level might kindle the interest of the high achieving students in biochemistry and genetics, the foundations of biotechnology.

Despite the type of students agriculture teachers are dealing with "the call for integration of academic and applied concepts" has been heard from both academic and vocational sources (Balsweid and Thompson, 1999). Furthermore there is evidence that indicate student performance increases when students are taught courses that integrate science and agriculture (Roegge and Russell, 1990). Balschweid (2002) also found that teaching biology using agriculture as the context moderately stimulated high school students in Indiana to consider careers in food systems and agriculture.

Science Credits for Bioscience Instruction

Some agriculture educators believe that science credits should be offered for agriscience instruction. Lehnert (1988) was of the opinion that agriscience should only be offered as a science credit if it is well integrated as a science, as in the case of an agriculture curriculum in Vicksburg, Michigan. According to Lehnert (1988), the teacher in Vicksburg was able to teach bioscience quite satisfactorily with the cooperation of the science department and offered science credit for it. Duval (1988) contended that many agriculture teachers could request and receive science credit provided they defined and developed new curricula for agriscience. The committee on Agricultural Education in Secondary Schools (1988) also recommended that agricultural courses sufficiently upgraded in science content could be credited as fulfilling the science requirements for high school graduation and college entrance, in addition to the core curriculum.

Amberson (1989), on the other hand, was of the opinion that agricultural educators should leave science to the scientific community. However, he believed that agriculture teachers should teach agriscience courses that could substitute lower level science courses, but not core science courses that were essential for college preparation. Vold (1988) and Rajasekeran (1989), in their studies, found some agriculture teachers who decided not to teach the biosciences because the principals of their schools would not give such instruction science credit. Blum (1996) was of the opinion that use of the school garden, as a part of the agriculture curriculum could be useful in teaching science by using practical examples in agriculture. His contention was that although science in schools is presented in the abstract, in practice, it is the more applied science that is beneficial to the producers. Hence, science teachers using a school garden could practically apply many biological and physical science principles that would help transfer learning.

The Role of Biotechnology in FFA and SAE

At the start of the agriculture curriculum reform in 1989, critics of the existing curriculum were of the opinion that it was still focused in the past. These critics believed that organization of activities by the "Future Farmers of America" (FFA) and supervised agriculture experience (SAE) intended to give the students some practical experience in their field, were also outdated. Duval (1988) contended that the national FFA organization, in its attempts to make activities relevant to the agriculture graduates in terms of preparing them for future employment, perceived agriscience and emerging technologies to be important for the future of agriculture and their organization. The FFA showed commitment to agriscience and emerging technologies by providing award programs to recognize efforts of participants with projects in these areas. Perry (1989) was also of the opinion that an active FFA program would give students of agriculture ideal forums in which to practice communication and presentation skills in presenting projects related to agriscience.

According to the Committee on Agricultural Education in Secondary Schools (1988), FFA was providing support in developing new science-based instructional materials and special activities to help students to better understand scientific and technological development important to the agricultural industries. This committee believed that the rapidly growing agricultural biotechnology industry would provide new SAE opportunities in urban and rural communities (Committee on Agricultural Education in Secondary Schools 1988). The "National Conference on Agriscience and Emerging Technologies" held in Orlando, Florida, in 1988 recommended that an agriscience center be organized at FFA summer camps (Williams and Pope, 1989). Burton (1989) also believed that SAE activities would provide students with the necessary exposure and experience in biotechnology, agriculture, animal science, and other areas important to students' academic and employment needs. Burton (1989) was of the opinion that students could develop further skills in plant science and greenhouse management through placement arranged by local agriculture teachers.

The NABC (Marshall, 1996) committee on education developed programs that stressed education of youth. The committee-suggested that aspects of biotechnology activities be incorporated into 4-H program and encouraged collaboration within the states to avoid duplication. Hamilton (2000), on a more global forum, supported the education of young people, citing the "Iowa Youth Institute" an offshoot of the World Food Prize, as having potential through its youth development programs to inspire young people to careers in public service. Hamilton (2000) contended that the youth development programs at the Iowa Youth Institute have greater potential of solving world food problems than biotechnology alone.

Biotechnology and Emerging Technologies

Smith (1989) indicated that rapidly evolving technologies in agriculture have always pressured agricultural educators to develop new curricula to keep up with the changes and biotechnology was no exception. Williams and Pope (1989) stated that the "National Conference on Agriscience and Emerging Technologies" held in Florida in 1988 also recommended the incorporation of scientific principles related to agriculture. Malpiedi (1989) considered agricultural educators to be in a unique position to help vocational agriculture students not only understand the ethics of biotechnology but also teach them basic science concepts that will prepare them for future employment in the rapidly growing field of biotechnology.

Smith (1989), in emphasizing the need to learn sciences basic to biotechnology, contended there were many biotechnology products that could be useful in the farmstead. He considered production of growth hormones, genetically engineered plants, new herbicide resistant crops, and genetically engineered microorganisms that could be used in food processing and techniques that will allow for sensitive monitoring of crops' micro-climate and accurate disease and pest forecasting as beneficial to the farmstead.

Harlander and Garner (1986) rightly predicted that by the year 2000 the world-wide market for biotechnology derived foods and agricultural products would be valued at tens or hundred billions of dollars. Johnson (1999), in describing the phenomenal development in the biological sciences in this century, compared it to what physics was in the twentieth century. The twentieth century could be known as the "Century of Physics" because it is in this era that Einstein's special and general theories of physics were developed. During this period physics became the dominant science producing nuclear energy and space travel. Johnson (1999), on the other hand, rightly contended that the twenty-first century could be known as the "Century of Biology". The discovery of the double helix DNA molecule in 1953 and the birth of the modern science of genetics started the epoch of biology. The 21^{st} century holds the possibilities for large-scale experiments in genetic engineering not just in crops and animals but in humans as well. This magnitude of development in biotechnology has been as a result of investment in extensive agricultural research by the public and private agencies that will result in a transformation of agricultural production practices (Day and Meagher, 1996).

These research efforts have opened new applications in agriculture. Therefore, new programs related to these applications should be instituted at both the secondary and post-secondary levels (Moss, 1989). According to Smith (1989), present and future students of agriculture must be made aware of both the beneficial and harmful effects of biotechnology. Jenitor (1989) considers learning basic sciences not only advantageous because of the availability of job opportunities, but also for practical purposes of problem-solving in the field. Jenitor (1989) cited the case of bovine leukemia, a disease caused by a virus, as difficult to diagnose and has no known treatment. He contended that basic knowledge on the nature of this virus and how it integrates into the chromosomes of infected animals could help producers identify and either segregate the diseased cattle or get rid of animals that could be infectious.

Biotechnology and Sustainable Agriculture

Borlaug (2000) emphasized the importance of technology in maintaining agricultural productivity at a level high enough to feed the world and at the same time preserve the environment. The states of Iowa and North Dakota (Iowa State Daily, 2000) held several panel sessions, among them world hunger an overview of Genetically Modified Organisms (GMO's) and agricultural biotechnology and its global potential to alleviate world hunger, and ethical and environmental safety issues. Schor (1994) contended that several issues have been raised against biotechnology but one of the greatest concerns, so far, is environmental safety and it's potential for the erosion of biodiversity. Krantz (2000) was also of the opinion that safety of biotech crops, particularly in the light of the case of Starlink, a bioengineered corn not meant for human consumption but had found its way in Taco Bell grocery store taco shells, was one of agriculture's most contentious issues.

Osborne and Dyer (2000), in their survey of students in agriscience and their parents, found that this group of students and their parents thought that agriculture can help protect the environment but were not sure how agriculture contributed to environmental deterioration. Critics of biotechnology are skeptical about the ability of this technology to develop crops that will utilize fewer pesticides while increasing productivity. Lappe and Bailey (1998) contended that to date, biotechnology has been used in a number of innovations that have produced agricultural products that are more consumer-friendly but very few have genuinely increased productivity. The problem of acceptability of some of these products has not been due to only poor consumer acceptability but also to poor marketing strategies of these products (Lappe and Bailey, 1998).

The European market and some opponents of biotechnology products in the United States would like these products to be labeled so that consumers are aware of the type of products they are purchasing (Walters, 1997). According to Anthan (2000), some scientists contend that labeling will be meaningless if the farmers growing bio-engineered crops have neighbors who are not growing these types of crops because of contamination through cross-pollination. Lappe and Bailey (1998) believed that some biotechnology products have great potential in sustainable agriculture but have been less widely promoted. They considered the development of corn and wheat lines that could be more insect and drought resistant of great potential in sustainable agriculture. If these crop lines are successful, it may be possible to achieve higher yields under a variety of conditions.

Lappe and Bailey (1998) believed that adoption of biotechnology should be conducted cautiously to avoid past mistakes where new technology was seen to be the panacea of all prevailing ills in agriculture. One case in point was that of over-intensive agriculture in the 1920s that resulted in the creation of the 'dust bowl' and other modern problems caused by agriculture, such as overuse of pesticides and fertilizers (Kirschenmann, 2000). The advocates of biotechnology would like to see more and more genetically engineered crops released and yet the long-term consequences of the whole shift to food crops containing herbicide- tolerant or *Bacillus thuringensis*- genes is still unknown. Goldburg et.al. (1990) believe that the Food and Drug Administration (FDA) which is entrusted with assuring food safety have been lax about developing specific procedures to screen genetically engineered foods for their safety and nutritional values. Lappe and Bailey (1998) also believed that researchers conducting biotechnology studies lack the motivation but not the technology of tracking the movement of their bio-engineered genes or how the chemical dependencies will affect other organisms in the micro-ecosystems. The nature of biotechnology also precludes that only certain types of farmers will find this technology profitable and viable for their farming operations. Lappe and Bailey (1998) were of the opinion that although the high cost of the bio-engineered crops is offset by reduced production costs it will only be economical for large-scale farmers with whom most of the biotechnology firms have tended to work. There is also an increasing level of skepticism among consumers of the benefits promised by this new technology (Hilyer, 1999). The use of pesticide-resistant crops to reduce crop loss is also of increasing global concern (Progressive Farmer, 1999) as well.

The Board on Agriculture Committee on Biotechnology, part of the National Association of State Universities and Land Grant Colleges (NASULGC) (Marshall, 1996) had some concerns with biotechnology research being currently dominated by the private sector. This committee contended that this trend had been encouraged by the lack of political will to adequately fund the public sector. Other groups are also concerned about the current imbalance in funding that exists between the public and private sector because it threatens the ability of the research system to maintain diversity (Herdt, 1997). The NASULGC's committee on biotechnology concurs that diversity is needed to develop sustainable technologies and practices that will increase agricultural productivity, conserve the natural resource base, protect the environment, and ensure social equity (Marshall, 1996). Goldburg et.al. (1990) are skeptical of the public sector biotechnology research creating meaningful diversity in their research. They contend that the research agenda in biotechnology in both the private and public sectors is driven by agribusiness specifically towards development of herbicide tolerant crops that favors agribusiness rather than sustainable alternatives of weed control.

The NASULGC's committee on biotechnology was of the opinion that sustainability is an essential good that can be promoted by the public sector (Marshall, 1996). This committee also stressed the importance of education of the general public about the unique contributions of agriculture to the U.S. economy and to the quality of life of all Americans. The committee was of the opinion that unless average Americans understand the contributions of these institutions to maintain safe, secure, and affordable food supply, support for the institutions will diminish in the future. Goldburg et.al. (1990) were of the opinion that the public sector should not use valuable tax dollars to fund research in further development of herbicide tolerant crops because this was a threat to sustainable agriculture and had serious implications to economic and social well being of the rural communities.

Summary

Agricultural production has undergone several changes in the last thirty years. The literature indicated that the production system that heavily depended on chemicals and machinery has moved to a system with an emphasis on the impact of these systems on the environment. The conventional methods of production rely on fossil fuels and produce compounds that have an undesirable effect on the environment. Biotechnology and other emerging technologies may have the potential to produce viable alternatives that would result in a reduction of chemical use. Public perceptions of biotechnology and the new emerging technologies have not been very positive. Education of the public is necessary so that it can accept these new technologies. It may be more effective to educate young people in order to build a foundation for an informed public. Integrating biotechnology and the biosciences into the agricultural education curriculum would be a good place to start. The exposure of students to these emerging technologies would illustrate more diverse careers in the agricultural industry that are open to students with varying aptitudes. Integrating biotechnology and bioscience into agricultural education could stimulate students to become more creative and innovative in solving practical production problems. It could stimulate interests of high achieving students to pursue academic professions in the agricultural sciences. Science and technology is a rapidly expanding industry whose only foreseeable limitation is a shortage of skilled manpower. Therefore, it is important that agricultural education integrate bioscience and biotechnology into its curriculum to give students a good foundation in the basic sciences so they can make use of these expanding employment opportunities in science and technology. Some agricultural education instructors, on the other hand, believe that science should be left to the scientist. Others still are of the opinion that biotechnology has not significantly improved agricultural productivity (Lappe and Bailey, 1998) and are skeptical of its potential to solve the world's food problems. On a more global forum some people believe that integrating all aspects of agricultural science, technology, and public service into youth programs is beneficial and has greater potential to solve the world's food problems than biotechnology alone (Hamilton, 2000).

The following research questions guided this study:

1. What are the perceptions of selected agricultural instructors regarding bioscience/ biotechnology?
2. To what extent are selected bioscience/biotechnology competencies appropriate for infusion into the agricultural education curriculum?
3. What inservice education is needed to help teachers infuse bioscience/ biotechnology into the curriculum?
4. How do teachers differ in their perceptions regarding bioscience/ biotechnology?

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to identify perceptions of secondary school agricultural instructors regarding the role of bioscience and biotechnology in the agricultural education curriculum in the North Central Region of the United States. The study sought to determine the degree to which teachers perceive competencies to bioscience /biotechnology could be infused into the agricultural education curriculum. Over the past several years' teachers have received some teaching materials to help them teach science and biotechnology in agriculture. Another of the objectives of the study was to determine the extent to which teachers were willing to expand instruction in bioscience /biotechnology related to agriculture, if provided additional materials and inservice training. The reform of the agriculture curriculum in secondary schools in the United States began in 1989, with the aim of infusing more science into agricultural education programs. This study sought to clarify the current status of the curriculum reform in the focus area of bioscience /biotechnology education in agriculture.

Research Design

The research design used in this study focused on the use of a descriptive survey. This method has been found to be useful as a means of gathering information for studying the attitudes and perceptions of people. The responses for the study were measured using a Likert-type scale. The information obtained from the study was analyzed to describe the situation and to assess the inter-relationships between variables that were the focus of the study.

Population and Sample

Because of limited resources available to conduct the research project, this study was confined to the North Central Region of the United States, which included the following states: Illinois, Iowa, Indiana, Kansas, Missouri, Minnesota, Michigan, South Dakota, North Dakota, Wisconsin, Ohio and Nebraska. Additionally, the similarity of curriculum content in the region was another factor considered. The target population for the study was 2,429 secondary school agricultural educators in the North Central Region of the U.S.A. The agricultural teachers who participated in this study were identified from the "Agriculture Teachers' Directory" for the year 2000, published by the National Association of Agricultural Educators. An adequate sample size for the study was determined to be 25% of the population (Krejcie, 1970). A proportionate stratified random sampling method was adopted in order to select a sample that was representative of the North Central Region. A proportionate sample of 25% was drawn from each state within the region. The total number of agriculture teachers in each state was determined and then 25% of the teacher population in each state was selected using a table of random numbers (Lohr, 1999). The total number of teachers used in the study was 610.

Instrumentation

The instrument used in this study was adapted from that developed and used by Rajasekeran (1989). The instrument contained questions that determined the perceptions held by agriculture teachers regarding biotechnology in agriculture. A list of biotechnology competencies based on topic areas and the curriculum guide developed by the Iowa Technical Committee on Biotechnology related literature and the experience of the researcher. These competencies were developed in seven broad disciplines of sciences basic to biotechnology (1) plant science, (2) genetics, (3) animal science, (4) microbiology, (5) sustainable agriculture, and (6) environmental science, and (7) food sciences. The following criteria were used to develop the knowledge and skills statements.

(a) Knowledge and skills directly contribute to the applied sciences.

(b) Knowledge and skills have a direct impact on student career opportunities.

(c) Knowledge and skills have a relationship to seven occupational areas of the agriculture industry (production, propagation, horticulture, agricultural products and processing, natural resources and conservation, sales and services, forestry and agricultural mechanics).

The major areas of competencies in the questionnaire were, plant sciences, genetics, food science, microbiology, environmental science, and sustainable agriculture. Knowledge and skills were reviewed and approved by the researchers' program of study members of committee from the Department of Agricultural Education, at Iowa State University.

The Likert-type scale with points ranging from strongly disagree to strongly agree was used to collect information regarding teacher perceptions in the following areas:

1. The instrument included questions on the perceptions of teachers regarding the infusion of bioscience /biotechnology into the agricultural education curriculum.
2. Extent to which this knowledge or skill area should be infused into the curriculum
3. Extent to which the teachers would increase instruction in this knowledge or skill area given additional instructional materials and in-service education.

In addition questions pertaining to the respondents' demographic information were asked. Demographic related questions were asked in order to obtain more in-depth knowledge of the participants in this study. This section contained an open space for the respondents to give suggestions or opinions related to the study. A copy of the instrument is located in Appendix B. The study was approved by the Iowa State University committee on the use of human subjects (Appendix A).

Validity and Reliability

Validity is defined as the appropriateness, meaningfulness, and usefulness of the inferences made from the scores of instruments (Ary et al, 1996). There were three types of validity established in this research study: face validity, content validity, and external validity. Face validity refers to the appropriateness of the instrument for the intended purpose and was established by incorporating feedback received from the agricultural education teachers of secondary schools during the pilot-testing stage of the instrument. Content validity refers to the meaningfulness of the instrument in measuring the intended human behavior. There are different types of content validity. This study was concerned with content-related validity. The agricultural education faculty in the researchers' program of study committee at Iowa State University critically reviewed the instrument for content validity and suggested changes to some of the questions for clarity and to further establish content validity. External validity refers to the generalizability of the findings to the target population. A random sample of participants was used for the study and this ensured that external validity was established. The survey was also pilot-tested with 20 randomly selected secondary school agricultural educators in Iowa. A factor analysis was conducted and construct-related evidence was obtained to further verify content validity for the survey instrument. Table 1 shows the rotated factor loadings for the perception statements. An examination of the perception statements was used to understand the nature of the three factors. To reduce subjectivity items with factor loadings equal or greater than 0.4 were considered most important when the factors were labeled. The three factors were labeled (1) agricultural education (2) knowledge and skills pertaining to the science basic to biotechnology and (3) biotechnology.

Reliability refers to the ability of the instrument to measure the same thing consistently from the subjects. Reliability of the survey instrument was verified by establishing the Cronbach's reliability coefficient from the pilot-test data. Table 2 shows the

Table1. Rotated factor loadings for agricultural instructors' perceptions of the role of bioscience/ biotechnology in the secondary school agricultural education curriculum

Perception Statement	Factor Loading
Factor one = Agricultural education	
The infusion of biotechnology into the agriculture curriculum strengthens FFA.	0.68
Infusion of more science into the curriculum exposes students to diversified career opportunities in agriculture.	0.67
Infusion of science basic to biotechnology is essential for agricultural education in secondary schools.	0.66
The infusion of biotechnology increases student interest in studying agricultural education.	0.66
Learning about biotechnology helps students in solving practical problems in agriculture.	0.64
The infusion of biotechnology helps in developing meaningful supervised agricultural experience programs.	0.63
Students should learn how to explain the processes that occur in plants and animals while learning biotechnology.	0.63
Factor two = Biotechnology	
It takes additional time for teachers to incorporate biotechnology into the study of agriculture.	0.75
Additional instructional materials are required for infusing biotechnology into the study of agriculture.	0.68
The infusion of biotechnology requires modification of the agricultural education curriculum.	0.60
The infusion of biotechnology requires more teacher inservice education.	0.59
Factor three = Science based knowledge skills	
Studying the sciences basic to agriculture helps students in developing skills in the related agriculture fields.	0.49
Learning basic sciences helps students better understand agricultural sciences.	0.42

Table1. Continued

I am interested in relating basic science skills and knowledge to agriculture.	0.27
Students are interested in learning the basic sciences as relate to agriculture.	0.20

reliability of the different sections of the questionnaire. The reliability of the instrument ranged from 0.57 to 0.97.

Analysis of Instrument Reliability

The instrument consisted of a general perception section and a series of bioscience /biotechnology competency statements from seven broad areas: (1) plant science, (2) genetics, (3) animal science, (4) microbiology, (5) food science, (6) sustainable agriculture, and (7) environmental education. The composite reliability coefficient for the instrument was computed using Cronbach's alpha. The general perception section had 15 items and had a reliability coefficient of .6796. The composite reliability coefficients were found to be 0.90 and over for most of the competency categories, except for the competency category of environmental education which was 0.57.

This category of competency may have been low because this was the first time that instructors had been asked this type of questions that sought to make a connection between agriculture and environmental education. The questions on environmental education were unfamiliar so the respondents may have been uncertain as to how to answer them. In addition there were fewer questions in this category compared to other categories and the nature of the questions could make them have a low reliability coefficient. However for purposes of educational research or making decisions about a particular group a lower reliability coefficient (in the range of 0.50-0.60) is considered acceptable.

Table 2. Composite reliability coefficients of bioscience /biotechnology competency areas

Disciplines	Number of Competency items	Reliability Coefficient [a]
Plant Science	18 items	0.9514
Genetics	30 items	0.9708
Animal Sciences	10 items	0.9058
Microbiology	16 items	0.9665
Food Science	16 items	0.9500
Sustainable Agriculture	8 items	0.9688
Environmental Education	6 items	0.5689

[a] Cronbach's alpha.

Therefore, for the purpose of this study, the reliability coefficient for environmental education at 0.57 was considered acceptable. Based on the magnitude of the composite reliability coefficients, the competency areas were considered adequate to measure the perceptions of the agricultural educators towards bioscience /biotechnology

Data Collection

The questionnaires were mailed to the participating agriculture teachers. A cover letter explaining the nature and scope of the study (Appendix B) and self- addressed-stamped envelope was enclosed. The participants in the study were asked to complete the questionnaire and return it to the researcher within three weeks of receipt of the instrument. A code number was assigned to each participant and it was marked in the corner of the last page of the questionnaire for identification and follow-up purposes only. A follow up letter along with another copy of the questionnaire was mailed to all participants of the study who failed to respond to the first mailing. A second follow-up was conducted three weeks after the first follow-up. A follow up letter along with another copy of the questionnaire was mailed to the participants of the study who failed to respond to the first and second mailing. A third follow-up was conducted as the final procedure to collect data from non-respondents. A follow up letter and a copy of the questionnaire was sent to the respondents who had not responded to the first three mailings. Table 3 shows the response rate of the respondents in the twelve different states.

Table 3. Rate of Return of Questionnaire by Respondent Groups

Respondent groups	Number of Questionnaires Mailed	Number of Questionnaires Returned	%Returned
Illinois	82	42	51.2
Indiana	49	32	65.3
Iowa	60	43	71.7
Kansas	40	17	42.5
Michigan	30	16	53.3
Minnesota	48	19	39.6
Missouri	70	34	48.6
Nebraska	32	18	56.2
North Dakota	22	12	54.5
Ohio	92	44	47.8
South Dakota	20	13	65.0
Wisconsin	65	35	53.8
Total	610	325	53.3

The number of questionnaires returned by the 610 sample of agricultural educators after the third mailing was 325. The response rate was 53.3%. Respondents who responded by the 20th of May 2001 after the first mailing were considered to be early respondents. Respondents who responded after the 20th of May 2001 after subsequent mailings were considered to be late respondents.

Statistical Analysis

Data collected from respondents was analyzed using the Statistical Package for the Social Sciences (SPSSx). A Cronbach's alpha was established for the biotechnology competencies to evaluate reliability of the instrument. The mean scores and standard deviations were computed for all the listed bioscience competencies to determine the degree to which the bioscience competencies should be infused into the agriculture curriculum. The mean and standard deviations of the competencies to determine the extent to which the agricultural educators would increase instruction in the listed bioscience competencies, given additional instructional materials and inservice training were also given. To test for the differences between the early respondents and late respondents, for the perceptions held for the infusion of bioscience /biotechnology into the agriculture curriculum a t-test was used at the 0.05 level of significance. The Spearman Rank correlation coefficient was used at the 0.05 level of significance to determine certain relationships between selected demographic factors and perceptions of agriculture teachers. A factor analysis was also conducted for the perceptions held by agricultural educators in this study to gather further evidence for content validity of the instrument.

A comparison of the perceptions of the agricultural education instructors based on their rate of response to the questionnaires is shown in Table 4. The results indicate that there was no difference between the early and late respondents for most of the perception statements.

Table 4. Means, standard deviations and t-values regarding perceptions held by early and late respondents to a questionnaire on biotechnology for agricultural educators in the North Central Region

Perceptions	Early Respondents (n=183)		LateRespondents (n=142)		t-value[b]
	Mean[a]	S.D.	Mean	S.D.	
Infusion of sciences basic to biotechnology is essential for agricultural education in secondary schools	4.11	0.79	4.14	0.72	-0.47
Learning basic science helps students better understand agricultural sciences.	4.26	0.61	4.29	0.61	-0.35
Students should learn how to explain the processes that occur in plants and animals while learning biotechnology.	4.35	0.55	4.30	0.55	0.86
Infusion of more science into the agricultural education curriculum would expose students to diversified career opportunities in opportunities in agriculture.	4.13	0.79	4.16	0.79	-0.30
Learning about biotechnology helps students in solving practical problems in agriculture	3.90	0.71	3.87	0.73	0.37
Studying the sciences basic to agriculture helps students in developing skills related to agriculture.	4.34	0.61	4.33	0.50	0.43
The infusion of biotechnology requires modification of the agricultural education curriculum.	3.82	0.88	3.71	0.87	1.10
The infusion of biotechnology requires more teacher inservice education	4.23	0.68	4.27	0.68	-0.38
The infusion of biotechnology increases student interest in studying agricultural education.	3.54	0.86	3.66	0.85	-1.33

Table 4. Continued

Students are interested in learning basic sciences as they are related to agriculture.	3.57	0.85	3.64	0.76	-0.78
I am interested in relating basic science skills and knowledge to agriculture	4.27	0.64	4.33	0.54	-0.82
It takes additional time for the teachers to incorporate biotechnology into the study of agriculture.	4.27	0.75	4.08	0.83	2.03 *
Additional instructional materials are required for infusing biotechnology into the study of agriculture	4.39	0.65	4.32	0.62	0.88
The infusion of biotechnology into agriculture curriculum will strengthen FFA.	3.39	0.95	3.67	0.86	-2.71
The infusion of biotechnology into agriculture helps develop meaningful supervised agricultural experience programs.	3.55	0.85	3.66	0.83	1.20

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D=Standard deviations [b] Equal variances assumed. * $p \leq 0.05$.

One statement showed that there was a statistically significant difference between the early and late respondents. This statement focused on taking additional time for the teachers to incorporate biotechnology into the study of agriculture. The mean for the early respondents for this statement was higher than that of the late respondents. This data could indicate that the early respondents saw a greater need for teachers to spend more time to integrate biotechnology into the study of agriculture.

In the plant science category of competencies in Table 5 the early and late respondents were compared to determine if there were any significant differences between the groups on what competencies they perceived to be important. There was only one competency that showed any significant difference between the two groups. This competency was "Demonstrate the selective action of herbicides".

Table 5. Means, standard deviations and t-values of competencies of plant science perceived to be important by early and late respondents to a questionnaire on biotechnology for agricultural educators in the North Central Region

Competency	Early Respondents (n=179)		Late Respondents (n=138)		t-value[b]
	Mean [a]	S.D.	Mean [a]	S.D.	
Conduct an experiment to demonstrate photosynthesis and respiration	4.19	0.74	4.21	0.59	-0.35
Explain the importance of apical meristem in growth	3.92	0.77	3.88	0.74	0.40
Describe how nitrogen fixation takes place in leguminous crops	4.26	0.59	4.07	0.68	2.69
Demonstrate the effect of growth hormones on the rate of sprouting of vegetatively propagated plants	4.21	0.72	4.12	0.52	1.21
Identify some plant growth regulators	4.09	0.65	4.06	0.56	0.46
Explain the process of transpiration	4.25	0.59	4.20	0.54	0.69
List the plant growth limiting factors	4.28	0.54	4.23	0.55	0.68
Demonstrate the selective action of herbicides	4.25	0.68	4.09	0.66	2.10*

[a] 1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5= Strongly agree S.D= Standard deviation [b] Equal variances assumed, * $p \leq .05$.

The early respondents had a higher mean of 4.25 than the late respondents with a mean of 4.06 as shown in Table 5.

Table 6 shows the means, standard deviations and t-values of competencies of genetics perceived to be important to the agricultural education curriculum. There were no significant differences between the early and late respondents in this category of competencies.

Table 6. Means, standard deviations and t-values of competencies of genetics perceived to be important by early and late respondents to a questionnaire on biotechnology for agricultural educators in the north Central Region

Competency	Early Respondents (n=179)		Late Respondents (n=138)		t-value[b]
	Mean[a]	S.D.	Mean	S.D.	
Distinguish between a plant and animal cell.	4.12	0.74	4.17	0.65	-0.55
Describe the process of tissue culture	4.17	0.73	4.19	0.66	-0.28
Describe the cloning of genes	4.01	0.85	4.07	0.74	0.61
Describe the different ways in which mutation takes place in plants	4.00	0.73	3.93	0.70	0.73
State Mendel's Law of inheritance	4.10	0.71	4.07	0.76	0.49
Explain the process of gene insertion	3.80	0.85	3.80	0.85	0.001
Describe the advantages of modern gene manipulation techniques	3.94	0.88	3.92	0.79	0.18
Explain the role of monoclonal antibodies in progeny testing	3.53	0.87	3.62	0.82	-0.91
Explain the process of transgensis	3.59	0.90	3.65	0.80	-0.63
Describe the role of gene splicing in the production of bovine and porcine somatrophin	3.67	0.97	3.78	0.78	-1.05
Explain the process of embryo transfer	4.21	0.74	4.19	0.62	0.34
Describe gene expression	4.12	0.74	4.04	0.70	0.99

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree S.D= Standard deviations [b] equal variances assumed. * $p \leq 0.05$.

The agricultural educators were compared on the basis of early and late respondents to determine if there was a significant difference on what competencies the different groups perceived to be important in the animal science category of competencies. There were no significant differences between the early and late respondents in any of the competency items as shown in Table 7.

Table 7. Means, stand deviations and t-values of competencies in animal science perceived to be important by early and late respondents to a questionnaire on biotechnology for agricultural educators in the North Central Region

Competency	Early Respondents (n=175)		Late Respondents (n=138)		t-value[b]
	Mean [a]	S.D.	Mean	S.D.	
Explain the Role of bovine growth hormones in milk production.	4.09	0.74	4.05	0.70	0.49
Explain the principle of immunization.	4.29	0.62	4.24	0.60	0.75
Demonstrate the use of vaccines against major animal diseases.	4.18	0.72	4.11	0.68	1.00
Explain the physiology of lactation egg production and meat production in animals.	4.25	0.73	4.26	0.62	-0.12

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree S.D= Standard deviation [b] Equal variances assumed. * $p \leq 0.05$.

In the category of competencies in microbiology the early and late respondents were compared to determine if there were any significant differences between the two groups on what competencies they perceived to be important to the agricultural education curriculum. There were no significant differences between the two groups on any of the competencies in this category as shown in Table 8.

Table 8. Means, standard deviations and t-values of competencies of microbiology perceived to be important by early and late respondents to a questionnaire on biotechnology for agricultural educators in the north Central Region

Competency	Early Respondents (n=180)		Late Respondents (n=138)		t-value[b]
	Mean[a]	S.D.	Mean	S.D.	
Describe different ways of classifying microorganisms related to agriculture.	3.89	0.76	3.79	0.74	1.23
Distinguish the difference between fungi and bacteria.	3.92	0.77	3.96	0.70	-0.56
Draw the structure of a selected fungus in agriculture.	3.58	0.86	3.47	0.83	1.10
Observe the structure of a bacterial cell under the microscope.	3.88	0.83	3.83	0.75	0.635
Distinguish the difference between autotrophic and heterotrophic microbes	3.62	0.95	3.67	0.80	-0.50
List beneficial microbes in agriculture.	4.08	0.80	3.98	0.70	1.11
Demonstrate culturing of microorganisms in the laboratory.	3.78	0.89	3.77	0.77	0.16
Identify nitrogen fixing organisms and explain how they fix nitrogen.	4.17	0.80	4.01	0.64	1.83

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D= Standard deviations [b] Equal variances assumed. * $p \leq 0.05$.

In the food science category of competencies the early and late respondents were compared to determine if there were any significant differences between the two groups. The results in Table 9 indicate that there were no significant differences between the two groups. However the means for the early respondents tended to be higher than those of the late respondents for all the competencies items in this category.

Table 9. Means, standard deviations and t-values of competencies of food science perceived to be important by early and late respondents to a questionnaire on biotechnology for agricultural educators in the north Central Region

Competency	Early Respondents (n=180)		Late Respondents (n=138)		t-value[b]
	Mean[a]	S.D.	Mean	S.D.	
Describe the importance of yeast in agriculture for product enhancement.	3.93	0.78	3.82	0.73	0.78
Identify the fungi that spoil fruits and vegetables.	3.95	0.79	3.92	0.72	0.79
Explain the microbial activity in milk and how it helps in formation of milk products.	4.01	0.76	3.99	0.74	0.76
Describe the process of fermentation.	4.08	0.69	3.99	0.73	0.69
Identify some artificial sweeteners that could be manufactured in industry using biotechnology.	3.83	0.85	3.81	0.79	0.85

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D. Standard deviations [b] Equal variances assumed.*p $\leq$ 0.05.

In the category of competencies in sustainable agriculture the early and late respondents were compared to determine if there were any significant differences between the two groups on what competencies they perceived to be important to the agricultural education curriculum. There were no significant differences between the two groups on any of the competency items in this category as shown in Table 10.

In the category of competencies in environmental education the early and late respondents were compared to determine if there were any significant differences between the two groups on what competencies they perceived to be important to the agricultural education curriculum. There were no significant differences between the two groups for any competencies in this category as shown in Table 11.

Table 10. Means, standard deviations and t-values of competencies of sustainable agriculture perceived to be important by early and late respondents to a questionnaire on bioscience/ biotechnology for agricultural educators in the North Central Region

Competency	Early Respondents (n=180)		Late Respondents (n=138)		t-value[b]
	Mean[a]	S.D.	Mean	S.D.	
Explain the use of resistance in the management of diseases, insects and weeds.	4.22	0.66	4.24	0.62	-0.29
Explain the use of natural enemies in the management of insects, diseases and weeds.	4.30	0.60	4.30	0.60	0.00
Describe the process of gene enhancement in the production of varieties suitable for specific environments.	3.98	0.80	4.03	0.68	0.60
Explain the biological properties of soil	4.27	0.67	4.19	0.70	1.03
Describe the importance of soil organic matter	4.34	0.59	4.31	0.60	0.34

[a] 1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5= Strongly agree. S.D.= Standard deviations [b] Equal variances assumed. * $p \leq 0.05$.

Table 12 shows a comparison between early and late respondents in the category of plant science competencies to determine if there is a significant difference between the two groups on what aspects of the competencies they would be willing to expand instruction if the agricultural instructors were given inservice education and additional instructional materials to integrate into the agriculture curriculum. There was a significant difference between the two groups on two items of competencies. The first one was "Describe how nitrogen fixation takes place in leguminous crops". The mean for the early respondents for this item of competency was higher in the early respondents at 4.23 compared to the late respondents at 4.05. The second item was "Demonstrate the selective action of herbicides".

Table 11. Means, standard deviations and t-values of competencies of environmental education perceived to be important by early and late respondents to a questionnaire on biotechnology for agricultural educators in the North Central Region

Competency	Early Respondents (n=178)		Late Respondents (n=138)		t-value[b]
	Mean[a]	S.D.	Mean	S.D.	
Explain the use of microorganisms in degrading the wastes in the environment	4.06	0.82	4.04	0.67	0.82
Describe the relationship between plants animals and microorganisms within a particular ecosystem	4.15	0.75	4.08	0.71	0.74
Explain the enzymatic activity of bacteria in decomposition of crop residues	3.99	0.72	3.96	0.74	0.72

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. Standard deviations. [b] Equal variances assumed. * $p \leq 0.05$

The mean for the early respondents for this item was higher at 4.27 compared to the late respondents at 4.06.

In the category of competencies of genetics a comparison was conducted between the early and late respondents using a t-test to determine if there were any significant differences between the two groups on what areas of competencies they would be willing to expand instruction if they were given inservice education and additional instructional materials to integrate into the agriculture curriculum. There were no significant differences between the two groups for any of the competencies in this category of competencies as shown in Table 13.

Table 12. Comparisons between early and late respondents' means, standard deviations and t-values of plant science competencies that would be included in the curriculum if instructors in the North Central Region were given inservice education

Competency	Early Respondents (n= 177)		Late Respondents (n=138)		t-value[b]
	Mean[a]	S.D.	Mean	S.D.	
Conduct an experiment to demonstrate photosynthesis and respiration	4.16	0.79	4.22	0.58	-0.69
Demonstrate the practice of hydroponics	4.16	0.82	4.12	0.74	0.54
Explain the importance of apical meristem in growth	3.91	0.81	4.93	0.68	-0.22
Describe how nitrogen fixation takes place in leguminous crops	4.23	0.65	4.05	0.69	2.39*
Demonstrate the effect of growth hormones on the rate of sprouting of vegetatively propagated plants	4.20	0.79	4.13	0.62	0.79
Identify some plant growth regulators	4.11	0.65	4.06	0.61	0.67
Explain the process of transpiration	4.18	0.63	4.15	0.58	0.48
List the plant growth limiting factors	4.24	0.65	4.19	0.54	0.77
Demonstrate the selective action of herbicides	4.27	0.68	4.06	0.74	2.63*

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D=Standard deviations [b] Equal variances assumed. * $p \leq 0.05$.

Table 13. Comparisons between early and late respondents' means, standard deviations and t-values of genetics competencies that would be included in the curriculum in the North Central Region if instructors were given inservice education

Competency	Early Respondents (n=177)		Late Respondents (n= 139)		t-value[b]
	Mean[a]	S.D.	Mean	S.D.	
Distinguish between a plant and animal cell	4.00	0.79	4.12	0.69	-1.499
Describe the function of DNA	4.07	0.76	4.15	0.71	-0.924
Describe the process of tissue culture	4.07	0.76	4.02	0.72	0.533
Describe the cloning of genes	4.04	0.81	4.00	0.82	0.413
Describe the different ways in which mutation takes place in plants	3.97	0.81	3.94	0.70	0.256
State Mendel's Law of inheritance	4.00	0.78	4.07	0.711	-0.781
Explain the process of gene insertion into germ cell lines	3.77	0.97	3.80	0.93	-0.250
Describe the advantage of modern gene manipulation techniques	3.91	0.93	3.88	0.83	0.300
Explain the role of monoclonal antibodies in progeny testing	3.55	0.92	3.64	0.81	-0.809
Explain the process of transgenesis	3.63	0.92	3.69	0.82	0.600
Describe the role of gene splicing in the production of bovine and porcine somatrophin	3.71	0.98	3.81	0.81	-0.896
Explain the process of embryo transfer	4.19	0.75	4.22	0.65	-0.288
Describe gene expression	4.13	0.75	4.01	0.72	1.41

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D= Standard deviations [b] Equal variances assumed. * $p \leq 0.05$

In the category of animal science competencies a comparison between the early and late respondents was conducted using a t-test to determine what areas of competencies they would be willing to expand instruction given inservice education and additional instructional materials to integrate into the agriculture curriculum. There were no significant differences between the two groups on any of the competencies in this category as shown in Table 14.

Table 14. Comparisons between early and late respondents' means, standard deviations and t-values of animal science competencies that would be included in the curriculum if instructors in the North Central Region were given inservice education

Competency	Early Respondents (n=174)		Late Respondents (n=137)		t-value[b]
	Mean[a]	S.D.	Mean	S.D.	
Explain the Role of bovine growth hormones in milk production	4.06	0.77	4.10	0.71	-0.607
Explain the principle of immunization	4.21	0.68	4.22	0.66	-0.18
Demonstrate the use of vaccines against major animal diseases	4.16	0.70	4.09	0.73	0.92
Explain the physiology of lactation egg production and meat production in animals	4.22	0.71	4.24	0.64	-0.22

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D= Standard deviations [b] Equal variances assumed. * $p \leq 0.05$.

Table 15 shows a comparison between early and late respondents in the category of microbiology competencies to determine if there is a significant difference between the two groups on what aspects of the competencies they would be willing to expand instruction if they were given inservice education and additional instructional materials to integrate into the agriculture curriculum. There were no significant differences between the two groups in any of the competency items in this category.

Table 15. Comparisons between early and late respondents' means, standard deviations and t-values of microbiology competencies that would be included in the curriculum if instructors in the North Central Region were given inservice education

Competency	Early Respondents (n= 174)		Late Respondents (n=137)		t-value[b]
	Mean[a]	S.D.	Mean	S.D.	
Describe different ways of classifying microorganisms related to agriculture	3.86	0.83	3.85	0.79	0.13
Distinguish the difference between fungi and bacteria	3.87	0.80	3.97	0.72	-1.11
Draw the structure of a selected fungus in agriculture	3.60	0.88	3.54	0.85	0.56
Observe the structure of a bacterial cell under the microscope	3.89	0.81	3.86	0.79	0.27
Distinguish the difference between autrophic and heterophic microbes	3.62	0.95	3.70	0.78	-0.74
List beneficial microbes in agriculture	4.02	0.81	3.96	0.71	0.76
Demonstrate culturing of microorganisms in the laboratory	3.77	0.89	3.79	0.77	-0.17
Identify nitrogen fixing organisms and explain how they fix nitrogen	4.14	0.77	4.02	0.66	1.23

[a] 1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5= Strongly agree, S.D=Standard deviations [b] Equal variances assumed. * $p \leq 0.05$

In the category of food science competencies a comparison between early and late respondents was conducted using a t-test to determine if there were any significant differences between the early and late respondents on what areas of competencies they would be willing to expand instruction if they were given inservice education and additional instructional materials to integrate into the agriculture curriculum. There were no significant differences between the early and late respondents on any of competencies in this category as shown in Table 16.

Table 16. Comparisons between early and late respondents' means, standard deviations and t-values of food science competencies that would be included in the curriculum if instructors in the North Central Region were given inservice education

Competency	Early Respondents (n=174)		Late Respondents (n=137)		t-value[b]
	Mean[a]	S.D.	Mean	S.D.	
Describe the importance of yeast in agriculture for product enhancement	3.96	0.76	3.81	0.73	1.76
Identify the fungi that spoil fruits and vegetables	3.97	0.79	3.88	0.75	1.09
Explain the microbial activity in milk and how it helps in formation of milk products	4.03	0.73	4.02	0.72	0.21
Describe the process of fermentation	4.07	0.75	4.03	0.70	0.53
Identify some artificial sweeteners that could be manufactured in industry using biotechnology	3.78	0.90	3.85	0.78	-0.74

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D= Standard deviations [b] Equal variances assumed. * $p \leq 0.05$

Table 17 shows the comparison between the early and late respondents using a t-test to determine if there were any significant differences between the two groups on what areas of competencies in sustainable agriculture they would be willing to expand instruction if they were given inservice education and additional instructional materials to integrate into the agriculture curriculum. There were no significant differences between the two groups.

Table 17. Comparisons between early and late respondents' means, standard deviations and t-values of sustainable agriculture competencies that would be included in the curriculum if instructors in the North Central Region were given inservice education.

Competency	Early Respondents (n=180)		Late Respondents (n=140)		t-value[b]
	Mean[a]	S.D.	Mean	S.D.	
Explain the use of resistance in the management of diseases, insects and weeds	4.22	0.69	4.25	0.67	-0.41
Explain the use of natural enemies in the management of insects, diseases and weeds	4.25	0.72	4.27	0.68	-0.17
Describe the process of gene enhancement in the production of varieties suitable for specific environments	3.99	0.86	4.01	0.67	-0.21
Explain the biological properties of soil	4.18	0.76	4.22	0.65	-0.51
Describe the importance of soil organic matter	4.27	0.71	4.30	0.69	-0.37

[a] 1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5= Strongly agree, S.D = Standard deviations [b] Equal variances assumed. * $p \leq 0.05$

In the category of environmental education competencies a comparison between early and late respondents was conducted using a t-test to determine if there were any significant differences between the early and late respondents on what areas of competencies they would be willing to expand instruction if they were given inservice education and additional instructional materials to integrate into the agriculture curriculum. There were no significant differences between the two groups in any of the competency items in this category of competencies as shown in Table 18.

Table 18. Comparisons between early and late respondents' means, standard deviations and t-values of environmental education competencies that would be included in the curriculum if instructors in the North Central Region were given inservice education

Competency	Early Respondents (n=178)		Late Respondents (n=138)		t-Value[b]
	Mean[a]	S.D.	Mean	S.D.	
Explain the use of microorganisms in degrading the wastes in the environment.	4.03	0.86	4.11	0.70	-0.80
Describe the relationship between plants animals and microorganisms within a particular ecosystem.	4.11	0.80	4.12	0.69	-0.10
Explain the enzymatic activity of bacteria in the decomposition of crop residues	3.98	0.80	4.17	1.92	-1.23

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D= Standard deviations [b] Equal variances assumed. * $p \leq 0.05$

Assumptions

The following assumptions were made regarding the study:

1. Accurate, objective, and unbiased information was provided by the agriculture teachers in each area of the questionnaire.
2. The perceptions of the participants of the study were representative of the agriculture teachers in the North Central Region of the United States.
3. Respondents evaluated the competencies in terms of a realistic perception of the role of biotechnology in the agricultural education curriculum.

Limitations of the Study

This study had the following limitations:

1. The study was limited to the science competencies that were considered basic to certain aspects of biotechnology in agriculture and did not consider other competencies related to secondary school agricultural education programs.
2. The competencies in the instrument reflected those considered important for secondary school agricultural education programs but did not include a complete list of the bioscience competencies as a whole.
3. This study was limited to teachers of agriculture in secondary schools; therefore, the results can only be generalized to agriculture teachers and not to core science teachers.

CHAPTER IV

FINDINGS

The overall purpose of this study was to identify perceptions of secondary school teachers of agriculture regarding the role of bioscience and biotechnology in the agricultural education curriculum in the North Central Region of the United States. This study sought to determine the degree to which teachers perceive competencies in the biosciences and biotechnology could be infused into the agriculture curriculum. Additionally, the study was to determine the extent to which competencies in biotechnology could be taught if inservice training and additional materials in biotechnology were provided to the teachers. Selected demographic factors were used to compare teacher responses in this study. The study identified 48 bioscience competencies that were divided into seven broad categories: (1) plant science, (2) genetics, (3) animal science, (4) microbiology, (5) food science, (6) sustainable agriculture, and (7) environmental education. In addition, the respondents provided demographic information including age, level of education attained, years of teaching experience, number of students enrolled in their particular programs, gender, preservice training in biotechnology or lack of pre-service training, inservice training as agricultural instructors or lack of in-service training.

The findings of this study are presented under the following sub-headings:

1. Demographic characteristics of the agricultural education instructors in selected secondary schools.
2. Analysis of perceptions held by agricultural instructors regarding the role of bioscience /biotechnology in agricultural education.
3. Analysis of competencies appropriate to bioscience /biotechnology that teachers perceived could be infused into the agriculture curriculum.
4. Degree to which instruction about biotechnology would be expanded by the agricultural educators given additional materials and inservice training.

5. Comparative analysis of various groups of respondents regarding their perceptions on selected bioscience competencies.
6. Open comments of the respondents.
7. Summary of the findings.

Demographic Characteristics

This study was a focus on the North Central Region of the U.S.A. Twelve states were included in the study: Illinois, Indiana, Iowa, Kansas, Michigan Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. The age distribution of the respondents who participated in this study is presented in Table 19. The average age of the agricultural educators in this study was 40.7 years. A doctor of philosophy was the highest level of education attained by some of the respondents in this study. It was found that 185 instructors had attained a Bachelor of Science degree, whereas 133 had earned a Master of Science Degree, and 4 percent had earned a Doctor of Philosophy Degree (Figure 1). Three of the instructors did not respond to the question.

Table 19. Age categories, frequencies and percentage of agricultural education instructors in secondary schools- in the North Central region of U.S.A. (N=325)

Age Category (years)	21-25	26-30	31-35	36-40	41-45	46-50	51-55	>56
Number of Respondents	26	41	34	53	60	46	48	17
Percentage of Respondents	8	12.7	10.5	16.3	18.4	14.0	14.7	5.4

Highest level of education attained by

agricultural educators

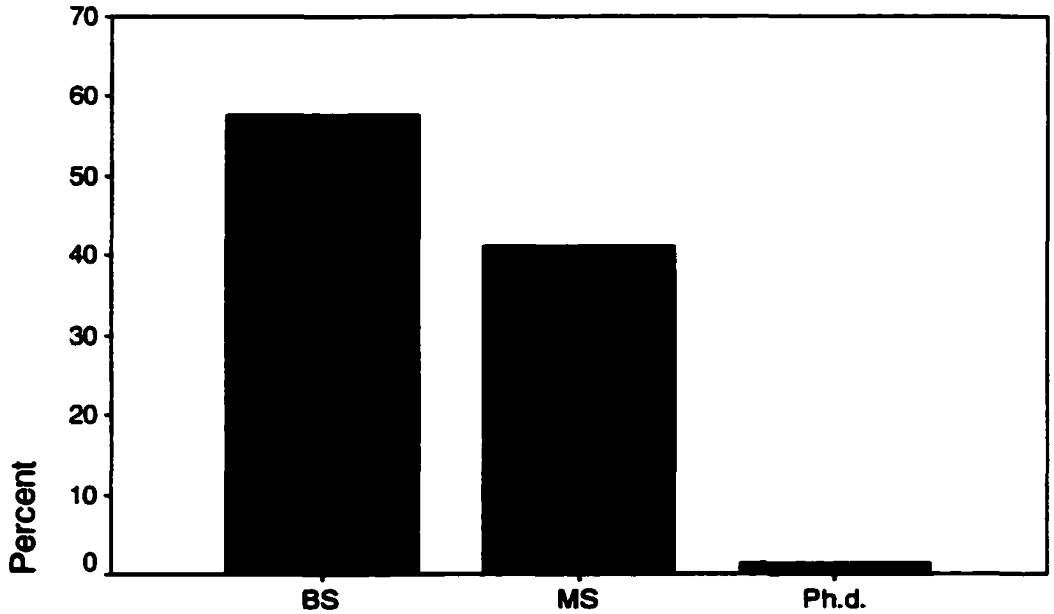

Figure 1. Highest level of education attained

The average teaching experience of the agricultural educators in the North Central region was 15.1 years. The range of years of experience possessed by these agricultural educators is shown in Table 20. Over forty-seven percent of the agricultural educators had sixteen years or more of experience as instructors. Over twenty-two percent of the teachers had teaching experience of five years or less.

Table 20. Frequencies and percentages of years of teaching experience of high school agriculture teachers in the North Central Region of the U.S. (N=325)

Years of Experience	1-5	6-10	11-15	16-20	21-25	26-30	>31
Number of Respondents	75	50	46	47	49	42	16
Percentage of Respondents	22.9	15.2	14.2	14.6	15.1	13.0	5.0

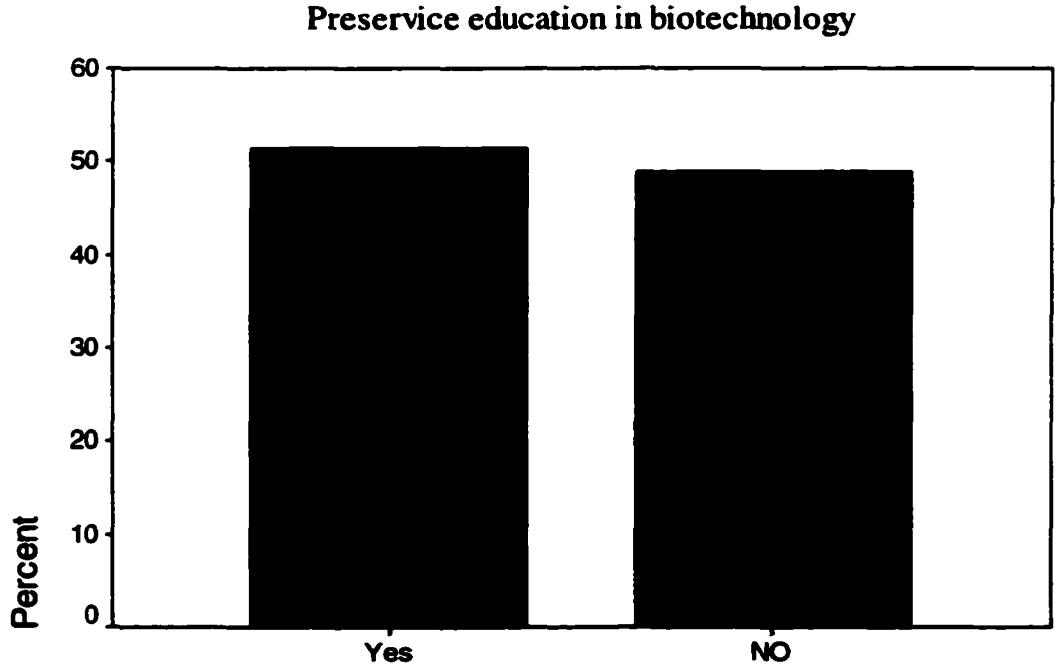

Figure 2. Distribution of agricultural educators with/ or without preservice education in biotechnology

Figure 2 shows the distribution of agricultural education instructors with or without pre-service training in biotechnology. Over fifty one percent of the teachers had preservice training in biotechnology and nearly forty –nine percent did not have any pre-service training in biotechnology. One person did not answer the question.

Figure 3 shows the distribution of instructors with inservice training related to biotechnology. Thirty-eight percent never had inservice training in biotechnology. Nearly sixty-two percent of the instructors had some in-service training related to biotechnology.

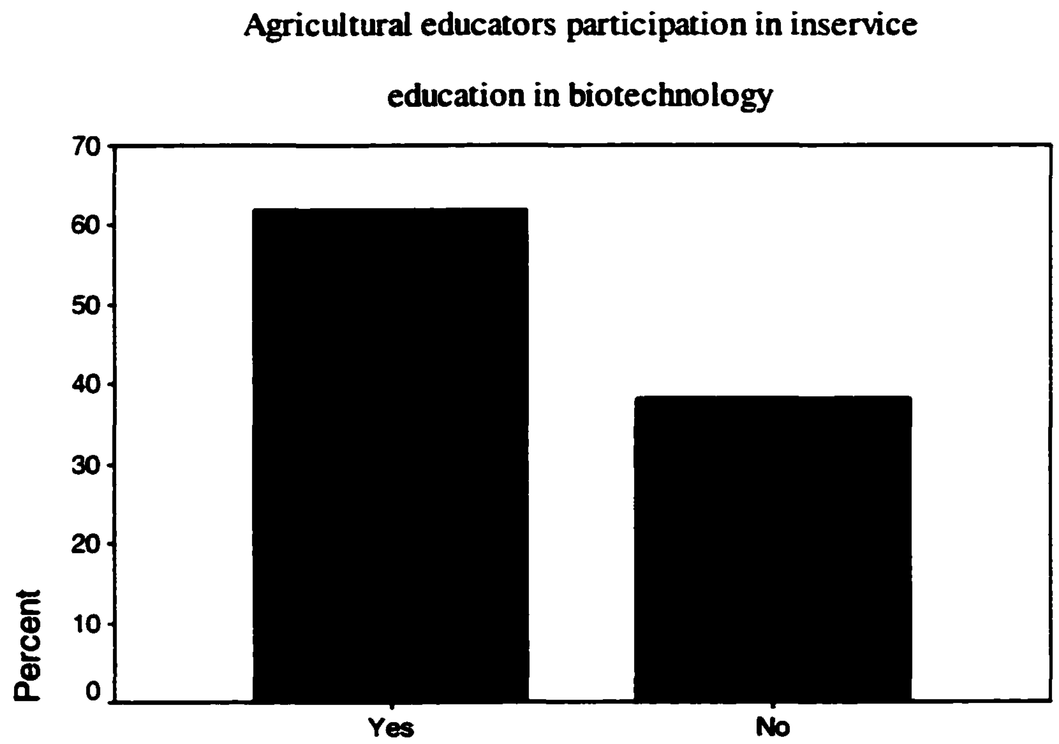

Figure 3. Inservice education in biotechnology

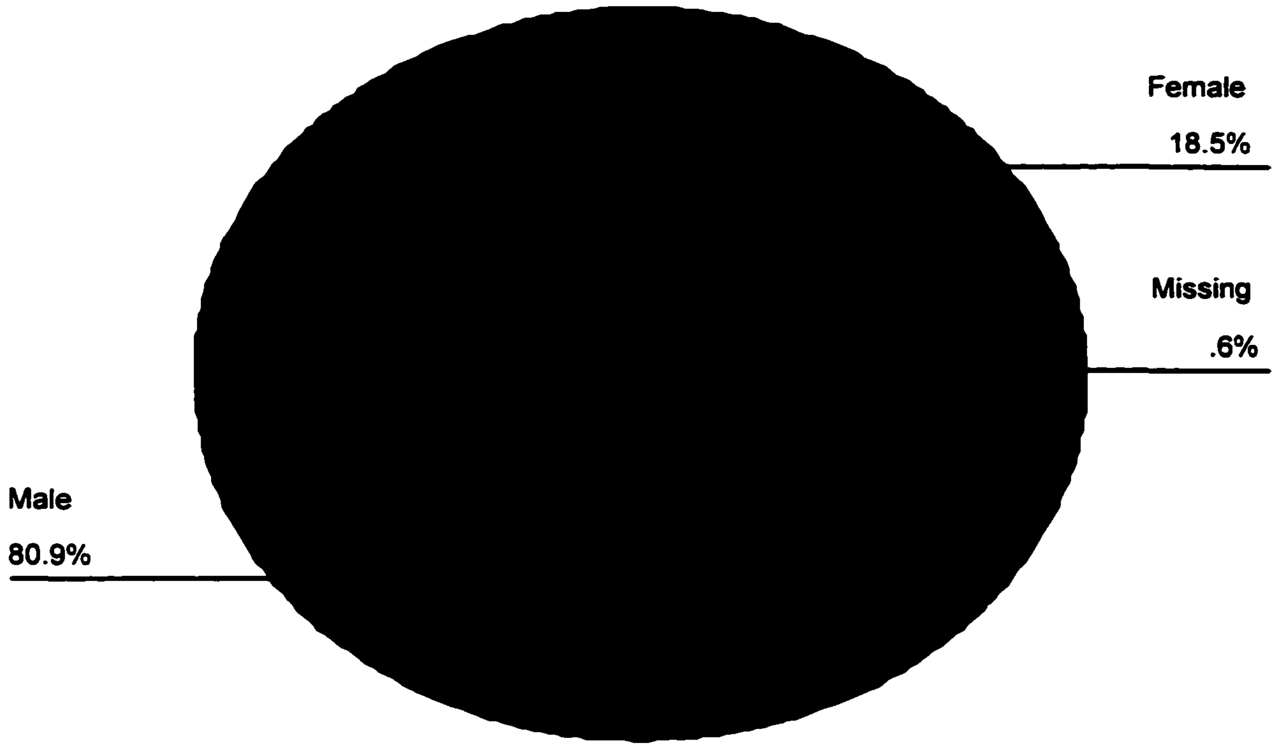

Figure 4. Distribution of agricultural education instructors based on gender

Two hundred and sixty three (80.9%) of the respondents were males and sixty (18.5%) were females. Two (0.6%) of the instructors did not respond to the question.

Analysis of Perceptions

Table 21 indicates the mean scores of the general perception ratings of the agricultural education instructors regarding the infusion of bioscience /biotechnology into the study of agriculture. It was interesting to note that 9 out of 15 perception statements had mean values of greater than 4.00, indicating that most of the respondents agreed with these statements. Six of the 15 statements had a mean of less than 4.00. However the ratings for the six statements were above 3.50 indicating a tendency to agree.

Table 21. Means and standard deviations on perceptions regarding bioscience / biotechnology held by agricultural educators in the North Central region (N=325)

Statements	Mean [a]	S.D.
Additional instructional materials are required for infusing biotechnology into the study of agriculture.	4.35	0.63
Students should learn how to explain the processes that occur in plants and animals while learning biotechnology.	4.33	0.55
Studying the sciences basic to agriculture helps students develop skills in related agriculture fields.	4.33	0.56
I am interested in relating basic science skills and knowledge to agriculture.	4.30	0.60
Learning basic sciences, chemistry, biology, physics, and others to better understand agricultural sciences.	4.28	0.60
The infusion of biotechnology requires more teacher in-service education.	4.24	0.68
It takes additional time for the teachers to incorporate biotechnology into the study of agriculture.	4.18	0.79
Infusion of more science into the agricultural education curriculum would expose students to diversified career opportunities in agriculture.	4.14	0.74
Infusion of sciences basic to biotechnology is essential for agricultural education in secondary schools.	4.13	0.76
Learning about biotechnology helps students solve practical problems in agriculture.	3.88	0.72
The infusion of biotechnology requires modification of the agricultural education curriculum.	3.77	0.88
The infusion of biotechnology increases student interest in studying agricultural education.	3.60	0.86
Students are interested in learning the basic sciences as they are related to agriculture.	3.60	0.81

Table 21. Continued

The infusion of biotechnology into agriculture helps develop meaningful supervised agricultural experience programs.	3.60	0.83
The infusion of biotechnology into the agricultural education curriculum would strengthen the FFA programs	3.51	0.92

[a]1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D=Standard deviations.

The lowest rated items focused on how biotechnology education could help supervised agricultural experience programs and FFA programs. Included in this list were items focused on student interest? These items had the highest standard deviation.

Many of the teachers tended to agree with the statement "infusion of biotechnology would require modification of the agricultural education curriculum" because this statement had a mean of 3.77. The teachers tended to agree that infusion of biotechnology would be an added incentive for students to study agricultural education. The statement "infusion of biotechnology increases student interest in studying agricultural education" had a mean of 3.60. These perceptions would pose a challenge to teachers who are working to change the curriculum using student interest as the main push for reform. It would also pose a challenge to teachers who wished to develop a new approach to agricultural education. Teacher perceptions tended to be neutral to agree that infusion of biotechnology would help develop meaningful supervised agricultural experience (SAE) programs or strengthen the FFA program. Statements pertaining to SAE and FFA had a mean of 3.60 and 3.51, respectively. These were the lowest rated items indicating less certainty about their level of agreement.

Table 22 shows the relative frequencies per response category for the perception statements on bioscience/ biotechnology. All the perception statements had more than fifty percent in the "agree" and "strongly agree" response categories combined. Indicating that the instructors agreed with all of the 15 perception statements.

Table 22. Individual item relative frequencies per response category for perceptions on bioscience / biotechnology held by agricultural educators in the North Central region (N=325)

Statements	% S.D.	% D.	% N	% A	% S.A.
Additional instructional materials are required for infusing biotechnology into the study of agriculture.	0	1.9	2.8	52.6	42.7
Students should learn how to explain the processes that occur in plants and animals while learning biotechnology.	0.0	0.3	3.7	59.1	36.9
Studying the sciences basic to agriculture helps students develop skills in related agriculture fields.	0	0.6	3.1	58.8	37.5
I am interested in relating basic science skills and knowledge to agriculture.	0	1.2	3.7	58.6	36.4
Learning basic sciences, chemistry, biology, physics, and others to better understand agricultural sciences.	0	0.90	5.3	59.1	34.7
The infusion of biotechnology requires more teacher in-service education.	0	2.2	7.2	54.5	36.1
It takes additional time for the teachers to incorporate biotechnology into the study of agriculture.	0	5.0	8.8	48.8	37.5
Infusion of more science into the agricultural education curriculum would expose students to diversified career opportunities in agriculture.	0.3	3.4	9.3	55.9	31.2
Infusion of sciences basic to biotechnology is essential for agricultural education in secondary schools.	0.9	2.5	10.2	55.4	31.1
Learning about biotechnology helps students solve practical problems in agriculture.	0.3	3.4	20.6	59.1	16.6
The infusion of biotechnology requires modification of the agricultural education curriculum.	1.3	9.4	16.6	56.3	16.6
The infusion of biotechnology increases student interest in studying agricultural education.	0.9	9.4	30.8	46.2	12.6

Table 22. Continued

Students are interested in learning the basic sciences as they are related to agriculture.	0.6	12.8	36.4	35.2	15.0
The infusion of biotechnology into the agricultural education curriculum would strengthen the FFA programs	0.6	12.8	36.4	35.2	15.0
Students should learn how to explain the processes that occur in plants and animals while learning biotechnology	0.0	0.3	3.7	59.1	36.1

S.D=Strongly disagree. D=Disagree. N.=Neutral. A.=Agree. S.A.= Strongly agree.

Data in Table 23 indicates the relationship between instructors' perceptions about teaching biosciences /biotechnology and selected demographic factors; namely, age of respondents, level of education attained, and number of years of experience teaching agriculture. The relationship was analyzed and the Spearman Rank correlation coefficient "R" was found to be greater than the probability value of (0.05) for two statements. One of the statements was correlated with the age of the respondents. This statement was (1) "Infusion of biotechnology increases student interest in studying agricultural education". This perception statement was found to be statistically significant at the (0.01) level. The statement was positively correlated to age indicating that as the age of the respondents increased, the level of agreement with this statement increased. Twelve of the R-values for the perception statements correlated with age had positive R- values; whereas, three of the statements had negative R-values. The statement "infusion of more science into the agricultural education curriculum would expose students to more diversified career opportunities in agriculture" correlated to the level of education of the respondents, had an R-value of –0.118, significant at the 0.05 level. However, the R-value was negative indicating a negative relationship between the level of education of the respondents and this perception statement.

Table 23. Relationship between agricultural educators' perceptions and demographic factors (N=325)

Statements	Age[a]	Education[a]	Years of teaching experience [a]
Infusion of sciences basic to biotechnology is essential for agricultural education in secondary schools.	0.053[a]	-0.058	0.008
Learning basic sciences (Chemistry Biology Physics and others) better understand agricultural sciences.	0.085	-0.042	0.061
Students should learn how to explain the processes that occur in plants and animals while learning biotechnology.	0.013	-0.055	-0.024
Infusion of more science into the agricultural education curriculum would expose students to diversified career opportunities in agriculture.	0.014	-0.133*	0.004
Learning about biotechnology helps students solve practical problems in agriculture.	0.087	0.065	0.068
Studying the sciences basic to agriculture helps students develop skills in related agriculture fields.	0.010	-0.027	0.014
The infusion of biotechnology requires modification of the agricultural education curriculum.	0.000	-0.028	-0.067
The infusion of biotechnology requires more teacher in-service education.	0.101	-0.049	0.041
The infusion of biotechnology increases student interest in studying agricultural education.	0.156**	-0.051	0.096
Students are interested in learning the basic sciences as they are related to agriculture.	0.082	-0.005	0.046
I am interested in relating basic science skills and knowledge to agriculture.	-0.038	-0.069	0.006

Table 23. Continued

It takes additional time for the teachers to incorporate biotechnology into the study of agriculture.	-0.028	-0.002	0.013
Additional instructional materials are required for infusing biotechnology into the study of agriculture.	0.033	-0.091	-0.025
The Infusion of biotechnology into the agricultural education curriculum strengthens FFA.	0.081	-0.033	0.021
The infusion of biotechnology into agriculture helps develop meaningful supervised agricultural experience programs	0.080	0.006	0.039

[a]Spearman rank correlation * $p \leq 0.05$. ** $p \leq 0.01$

Most of the perception statements, when correlated to the level of education had negative R-values. There were only two statements with positive R-values for this demographic factor. There were no significant R-values obtained between the perception statements and the years of experience held by the agricultural education instructors.

Most of the perception statements, when correlated against the number of years the agricultural educators had taught in high school, gave positive R-values; a few of the statements had negative values. The three statements that gave negative R-values were (1) students should learn how to explain the processes that occur in plants and animals while learning biotechnology, (2) the infusion of biotechnology requires modification of the agricultural education curriculum, (3) additional instructional materials are required for infusing biotechnology into the study of agriculture. This indicates that as the number of years of experience of teaching high school increases the level of agreement with the statements that dealt specifically with biotechnology decreased. This indicates that the instructors did not perceive these areas to be very important for the agricultural education curriculum. On the other hand the statements that were positively correlated indicate that the teachers tended to agree with them as the number of years of experience as instructors increased.

Analysis of Perceived Bioscience /Biotechnology Competencies

One of the objectives of this study was to measure the extent to which teacher's perceived bioscience and biotechnology should be infused into the agriculture curriculum. Another objective was to determine the extent to which competencies in biotechnology would be taught if inservice training and additional materials were provided to the teachers. Data pertaining to these objectives are organized and presented in Table 8 to 21. The mean scores and standard deviations for each of the competencies were grouped into seven broad categories 1) plant science, 2) genetics, 3) animal science, 4) microbiology, 5) food science, 6) sustainable agriculture, and environmental education. These seven broad categories were used because they have a relationship to seven occupational areas of the agricultural industry (propagation, horticulture, agricultural products and processing, natural resource and conservation, sales and services, forestry and agricultural mechanics). Tukey's method was used as a post-hoc analysis to determine if significant statistical differences existed among the teachers by states with respect to each of the seven categories.

There were nine items in the plant science category as shown in Table 23. The plant science competency "List plant growth limiting factors" received the highest mean rating by the respondents with a mean of 4.26.The process of transpiration received the second highest rating of 4.22. The lowest rating in the plant science category was given to the statement "Explain the importance of apical meristem in growth" with a mean of 3.90. The composite mean rating for plant science was 4.18.

The area of genetics consisted of 13 items (Table 24). The respondents in this study gave the highest rating of 4.20 to the statement "Explain the process of embryo transfer" as knowledge that should be infused in the agriculture curriculum. The second rated item was

"Describe the function of DNA" with a mean of 4.18. The lowest rated item was "Explain the role of monoclonal antibodies in progeny testing" with a mean of 3.56. The overall mean rating for the genetics category was 4.15.

Table 24. Means, standard deviations and relative frequencies of individual items for plant science competencies as rated by high school agricultural instructors in the North Central region of the U.S.A. (N=325).

Competencies	Mean [a]	S.D.	% 1	% 2.	% 3.	% 4.	% 5
List plant growth limiting factors.	4.26	0.54	0	0.6	3.2	65.5	30.7
Explain the process of transpiration.	4.22	0.57	0	0.9	4.4	65.7	28.9
Conduct experiment to demonstrate photosynthesis and respiration.	4.21	0.67	0.6	1.3	7.0	59.2	31.8
Describe how nitrogen fixation takes place in leguminous crops.	4.18	0.64	0	1.3	9.3	60.1	29.4
Demonstrate the effect of growth hormones on the rate of sprouting of vegatively propagated plants.	4.17	0.64	0	1.9	7.6	61.5	29.0
Demonstrate the selective action of herbicides.	4.17	0.67	0	2.5	7.6	59.6	30.3
Demonstrate the practice of hydroponics.	4.13	0.72	0.3	2.2	11.4	54.5	28.6
Identify some plant growth regulators.	4.07	0.61	0.3	1.3	9.4	68.6	20.4
Explain the importance of apical meristem in growth.	3.90	0.76	0.3	4.0	19.1	54.5	18.5
Composite Mean	4.18						

[a]1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree S.D. = Standard deviations..

Table 25. Means, standard deviations and relative frequencies of individual items for genetics competencies as rated by high school agricultural instructors in the North Central region of the U.S.A. (N=325).

Competencies	Mean[a]	S.D.	% 1	% 2	% 3	% 4	% 5
Explain the process of embryo transfer.	4.20	0.68	0.6	1.3	7.6	58.1	32.4
Describe the function of DNA.	4.18	0.70	0	1.9	11.4	53.3	33.4
Distinguish between a plant and animal cell.	4.14	0.70	0.3	2.2	9.5	58.4	29.3
State Mendel's Law of inheritance.	4.08	0.73	0.6	2.2	12.3	57.3	27.5
Describe the process of tissue culture.	4.08	0.73	0.3	2.8	12.7	57.0	27.2
Describe gene expression.	4.08	0.72	0.3	2.8	11.4	58.5	26.9
Describe cloning of genes.	4.03	0.81	0.9	3.8	13.6	54.1	27.5
Describe the different ways in which mutation takes place in plants.	3.95	0.71	0	4.1	15.5	61.1	19.3
Describe the advantages of modern gene manipulation techniques.	3.93	0.84	1.3	4.1	19.0	51.6	24.1
Explain the process of gene insertion into germ cell lines.	3.80	0.85	0.6	7.6	21.1	52.1	18.6
Describe the role of gene splicing in the production of bovine and porcine somatotrophin hormones.	3.71	0.89	1.6	7.3	26.3	47.3	17.5
Explain the process of transgenesis.	3.61	0.85	1.0	8.6	31.5	45.5	13.4
Explain the role of monoclonal antibodies in progeny testing.	3.56	0.85	0.3	11.1	31.6	45.3	11.2
Composite Mean	4.15						

[a]1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D= Standard deviations.

All the four items for the animal science competency area had mean ratings greater than 4.00 (Table 26). The highest rated item was "Explain the principles of immunization" with a mean of 4.28 and the lowest rated item was "Explain the role of bovine growth hormones in milk production" with a mean of 4.07. The overall mean for this category was 4.17.

Table 26. Means and standard deviations and relative frequencies of individual items for animal science competencies as rated by high school agricultural instructors in the North Central region of the U.S.A. (N=325)

Competencies	Mean[a]	S.D.	% 1	% 2	% 3	% 4	% 5
Explain the principles of immunization.	4.28	0.61	0.3	0.6	5.1	60.0	34.0
Explain the physiology of lactation; egg production and meat production in animals.	4.25	0.68	0.6	1.0	7.0	55.2	36.2
Demonstrate the use of vaccines against major animal diseases.	4.15	0.70	0.3	2.2	9.6	57.5	30.4
Explain the role of bovine growth hormones in milk production.	4.07	0.72	0.6	2.2	12.1	59.1	25.9
Composite Mean	4.17						

[a]1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D= Standard deviations.

The microbiology category had 8 items (Table 27). The respondents gave the item "Identify nitrogen- fixing organisms and explain how they fix nitrogen" the highest rating. It had a mean of 4.10 as shown in (Table 11). The item rated second was "List beneficial microbes in agriculture" had a mean of 4.04. The lowest rated item was "Draw the structure of a selected fungus in agriculture" with a mean of 3.54. The overall mean for this category was 3.84.

Table 27. Means, standard deviations and relative frequencies of individual items for microbiology competencies as rated by high school agricultural instructors in the North Central region of U.S.A. (N=325)

Competencies	Mean[a]	S.D.	% 1	% 2	% 3	% 4	% 5
Identify nitrogen-fixing organisms and explain how they fix nitrogen.	4.10	0.74	0.3	2.5	13.2	54.7	29.2
List beneficial microbes in agriculture.	4.04	0.76	0.3	3.5	14.5	55.7	25.8
Distinguish the difference between fungi and bacteria.	3.93	0.74	0	3.8	19.3	56.3	20.6
Observe the structure of a bacterial cell under the microscope.	3.86	0.80	0.3	5.3	21.7	53.5	19.2
Describe different ways of classifying microorganisms related to agriculture.	3.85	0.75	0	4.7	22.8	55.4	17.1
Demonstrate culturing of microorganisms in the laboratory.	3.78	0.84	0.3	7.2	25.2	49.1	18.2
Distinguish the difference between autotrophic and hetrotrophic microbes.	3.64	0.89	1.3	7.5	33.5	41.2	16.4
Draw the structure of a selected fungus in agriculture.	3.54	0.85	0.3	10.1	37.7	39.6	12.3
Composite Mean	3.84						

[a]1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree S.D= Standard deviations.

The item (1) "Describe the process of fermentation" had the highest rating of 4.04 in the food science category (Table 28). The item "identify some artificial sweeteners that could be manufactured by industry using biotechnology had the lowest mean of 3.82. The overall mean rating in the food science category was 3.94.

Table 28. Means and standard deviations and relative frequencies of individual items for food science competencies as rated by high school agricultural instructors in the North Central region of the U.S.A. (N=325)

Competencies	Mean[a]	S.D.	% 1	% 2	% 3	% 4	% 5
Describe the process of fermentation.	4.04	0.71	0	2.2	16.1	56.6	25.0
Explain the microbial activity in milk and how it helps in formation of milk products.	4.00	0.75	0.3	2.8	17.4	55.1	24.4
Identification of fungi that spoil fruits and vegetables.	3.93	0.75	0	4.1	19.9	54.3	21.8
Describing the importance of yeast to agriculture for product enhancement.	3.88	0.76	0.3	3.2	24.0	53.3	19.2
Identify some artificial sweeteners that could be manufactured by industry using biotechnology.	3.82	0.82	0.6	6.6	20.5	54.3	18.0
Composite Mean	3.94						

[a]1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D= Standard deviation.

In the sustainable agriculture category, the item "describe the importance of soil organic matter" received the highest rating with a mean of 4.32, (Table 29). The items in this category had the highest rating compared to any of the other categories. The item with the lowest mean (4.00) was "Describe the process of gene enhancement in the production of varieties suitable for specific environments". The overall mean for this category was 4.20.

The environmental education had only three items and they all received mean ratings above 4.00 (Table 30). The highest rated item was "Describe the relationship between plants, animals and microorganisms within a particular ecosystem" with a mean of 4.11. The lowest rated item was "Explain the enzymatic activity of bacteria in the decomposition of crop residue" with a mean of 4.00. The overall mean rating for this category was 4.06.

Table 29. Means and standard deviations and relative frequencies of individual items for sustainable agriculture competencies as rated by high school agricultural instructors in the North Central region of the U.S. A. (N=325)

Competencies	Mean[a]	S.D	% 1	% 2	% 3	% 4	% 5
Describe the importance of soil organic matter.	4.32	0.61	0	0.9	5.0	54.6	39.4
Explain the use of natural enemies in the management of insects, diseases, and weeds.	4.30	0.59	0	0.3	6.3	56.6	36.9
Explain the biological properties of soil.	4.24	0.68	0.6	0.9	7.5	55.9	35.0
Explain the use of resistance in the management of diseases, insects, and weeds.	4.22	0.64	0	0.9	8.8	56.6	33.8
Describe the process of gene enhancement in the production of varieties suitable for specific environments.	4.00	0.74	0.3	3.4	15.6	57.2	23.4
Composite Mean	4.20						

[a]1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5= Strongly agree S.D= Standard deviations.

Table 30. Means and standard deviations and relative frequencies of individual items for environmental education competencies as rated by high school instructors in the North Central region of the U.S.A. (N=325)

Competencies	Mean[a]	S.D.	% 1	% 2	% 3	% 4	% 5
Describe the relationship between plants and animals and microorganisms within a particular ecosystem.	4.11	0.73	0	3.5	10.8	56.3	29.4
Explain the use of microorganisms in degrading wastes in the environment.	4.04	0.76	0.3	3.5	13.9	55.4	26.9
Explain the enzymatic activity of bacteria in decomposition of crop residues.	4.00	0.73	0	3.2	18.0	56.6	22.2
Composite Mean	4.06						

[a]1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5= Strongly agree, S.D= Standard deviations.

Analysis of expansion in instructions

The third objective of this study was to determine the extent to which instruction in selected bioscience competencies would be increased, if teachers were provided additional materials and inservice training. This objective is focused on the need for inservice education. To follow up on teacher willingness to expand instruction in selected areas of biotechnology inservice education will be necessary. Data pertaining to this objective are organized and presented in Tables 31-37.

The instructors indicated a willingness to expand instruction in the area of plant sciences if they were provided with additional materials and inservice education in biotechnology. The three competency items that received the highest ratings were (1) "to list plant growth limiting factors" with a mean of 4.22 (Table 31). (2) "To demonstrate photosynthesis and respiration in the study of agriculture" with a mean of 4.19 and (3) "to demonstrate the selective action of herbicides" with a mean of 4.18. (Table 31). The lowest mean was given on the item "Explain the importance of apical meristem in growth" with a mean of 3.92. The overall mean of the plant science competencies that teachers perceived a need for inservice education was 4.13.

In the area of genetics the items with the highest ratings were (1) "Explain the process of embryo transfer" with a mean of 4.20 (Table 32). (2) "Describe the function of DNA" with a mean of 4.10 (Table 31). On the other hand, "to explain the role of monoclonal antibodies in progeny testing" had the lowest rating with a mean of 3.59. The overall mean for this category of competencies was 3.94

Table 31. Means, standard deviations and relative frequencies of individual items for ratings of plant science competency areas in the North Central region based on high school agricultural instructors' willingness to expand instruction in biotechnology if provided inservice education (N=325)

Competencies	Mean [a]	S.D.	% 1	% 2	% 3	% 4	% 5
To list the plant growth limiting factors.	4.22	0.60	0	0.6	7.6	60.8	30.9
To demonstrate photosynthesis and respiration in the study of agriculture.	4.19	0.70	0.6	1.9	7.3	57.8	32.4
To demonstrate the selective action of herbicides.	4.18	0.71	0	2.2	11.1	53.2	33.4
To demonstrate the effect of growth hormones on the rate of sprouting of vegetatively propagated plants.	4.17	0.71	0.3	1.9	10.8	53.8	33.1
To explain the process of transpiration.	4.17	0.61	0	0.3	10.4	61.1	28.2
To describe how nitrogen fixation takes place in leguminous crops.	4.15	0.67	0.3	1.3	10.2	59.1	29.1
To demonstrate the practice of hydroponics in crop production.	4.14	0.78	0.3	3.2	13.0	48.9	34.6
To identify some growth regulators.	4.08	0.64	0	1.6	11.7	63.3	23.4
To explain the importance of apical meristem in growth.	3.92	0.75	1.0	2.2	20.1	56.9	19.8
Composite Mean	4.13						

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D=Standard deviations.

Table 32. Means, standard deviations and relative frequencies of individual items for ratings of genetics competency areas in the North Central region based on high school agricultural instructors' willingness to expand instruction in biotechnology if provided inservice education (N=325).

Competencies	Mean[a]	S.D.	% 1	% 2	% 3	% 4	% 5
To explain the process of embryo transfer.	4.20	0.70	0.6	1.0	9.9	54.3	34.2
To describe the function of DNA.	4.10	0.74	0	1.9	16.5	50.5	31.1
To describe gene expression.	4.07	0.74	0.6	1.9	14.1	56.1	27.2
To describe the process of tissue culture.	4.06	0.75	0.6	1.6	16.9	53.5	27.4
To distinguish the difference between a plant and an animal cell	4.04	0.74	0.3	2.5	16.2	54.1	26.8
To describe the cloning of genes.	4.03	0.82	0.3	4.1	17.5	48.6	29.5
To state Mendel's law of inheritance.	4.03	0.75	0.3	2.2	17.8	52.9	26.8
To describe the different ways in which mutation takes place in plants.	3.96	0.76	0.3	3.2	19.2	54.6	22.7
To describe the advantages of modern gene manipulation techniques.	3.90	0.88	2.2	3.2	21.4	48.6	24.6
To explain the process of gene insertion into germ cell lines.	3.78	0.95	2.2	7.6	22.3	45.2	22.6
To describe the role of gene splicing in production of bovine and porcine somatrophin.	3.75	0.92	1.9	6.1	27.2	44.4	20.4
To explain the process of transgenesis.	3.65	0.87	1.6	7.0	30.7	45.7	15.0
To explain the role of monoclonal antibodies in progeny testing.	3.59	0.87	1.3	9.0	31.7	45.2	12.8
Composite mean	3.94						

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D=Standard deviations.

In the area of animal science competencies, all items had means above 4.00. The item with the highest rating was "to explain the physiology of lactation, egg production and meat production in animals" with a mean of 4.33 (Table 33). The lowest rated item was "to explain the role of bovine growth hormones in milk production" with a mean of 4.08 (Table 32). The teachers tended to agree that they would be willing to expand instruction in this category of competencies if they were provided with additional materials and inservice training. The grand mean score for this category of competency was 4.16.

Table 33. Means, standard deviations and relative frequencies of individual items for ratings of animal science competency areas in the North Central region based on high school agricultural instructors' willingness to expand instruction in biotechnology if provided inservice education (N=325).

Instruction in animal science	Means [a]	S.D.	% 1	% 2	% 3	% 4	% 5
To explain the physiology of lactation, egg production and meat production in animals.	4.23	0.67	0	1.0	10.9	52.1	36.0
To explain the principle of immunization.	4.22	0.67	0.3	1.3	8.0	56.9	33.4
To demonstrate the use of vaccines against major animal diseases.	4.13	0.71	0.3	2.3	11.3	56.6	29.6
To explain the role of bovine growth hormones in milk production.	4.08	0.74	0.6	2.3	13.2	56.1	27.7
Composite Mean	4.16						

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D.= Standard deviations.

The category of microbiology competency items received the lowest ratings compared to the other six areas with only two items with means above 4.00 (Table 34). The two statements with the highest ratings were (1) "to identify nitrogen-fixing organisms and to explain how they fix nitrogen" with a mean of 4.09.

Table 34. Means, standard deviations and relative frequencies of individual items for ratings of microbiology competency areas in the North Central region based on high school agricultural instructors' willingness to expand instruction in biotechnology if provided inservice education (N=325)

Competencies	Mean [a]	S.D.	% 1	% 2	% 3	% 4	% 5
Identify nitrogen-fixing organisms and to explain how they fix nitrogen.	4.09	0.72	0.3	1.9	14.6	54.9	28.3
Learn more about beneficial microbes in agriculture.	4.00	0.77	1.0	1.9	18.0	55.0	24.1
Distinguish the difference between fungi and bacteria.	3.92	0.77	0.3	3.8	20.4	54.6	20.8
Recognize the structure of a bacterial cell under the microscope.	3.88	0.80	1.0	3.8	21.9	53.3	20.0
Describe different ways of classifying microorganisms in agriculture.	3.85	0.81	1.0	4.5	21.8	53.8	18.9
Demonstrate culturing of microorganisms in the laboratory.	3.78	0.84	1.0	6.0	24.8	50.5	17.8
Distinguish between autotrophic and heterotrophic microbes.	3.66	0.88	1.9	5.7	33.3	43.2	15.9
Learn more about selected fungi in agriculture.	3.58	0.87	1.0	8.0	37.7	39.0	14.4
Composite Mean	3.84						

[a]1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D=Standard deviations.

(2) "Enable students to learn more about beneficial microbes in agriculture" with a mean of 4.00. The item with the lowest mean in this category was "to learn about selected fungi in agriculture" with a mean of 3.58.

The overall mean ratings for the willingness of instructors to expand instructions in microbiology given additional materials and in-service training was 3.84.

The area of food science competencies received relatively lower ratings compared to the other categories of competencies with the exception of microbiology which had the lowest ratings of all the categories. There were only two items with means above 4.00 (Table 35). These items were (1) "to describe the process of fermentation" with a mean of 4.05 (2) "to explain the microbial activity in milk and how it helps in the formation of milk

Table 35. Means and standard deviations and relative frequencies of individual items for ratings of food science competency areas in the North Central region based on high school agricultural instructor's willingness to expand instruction in biotechnology if provided inservice education (N=325)

Competencies.	Mean[a]	S.D.	% 1	% 2	% 3	% 4.	% 5
Describe the process of fermentation.	4.05	0.73	0	2.2	17.2	53.5	27.1
Explain the microbial activity in milk and how it helps in the formation of milk products.	4.03	0.72	0	2.6	16.9	55.3	25.2
Identify the fungi that spoil fruits and vegetables.	3.93	0.78	0	4.2	21.4	51.8	22.7
Describe the importance of yeast in agriculture for product enhancement.	3.89	0.74	0.3	2.5	24.4	52.8	19.9
Identify some artificial sweeteners that could be manufactured by industry using biotechnology.	3.80	0.84	1.0	6.7	21.9	51.7	18.7
Composite Mean	3.94						

[a]1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D=Standard deviations.

Products" with a mean of 4.03 (Table 35). The item with the lowest rating was "to identify some artificial sweeteners that could be manufactured by industry using biotechnology" with a mean of 3.80. The overall mean rating for instructors' willingness to expand instruction in food science if provided with additional materials and in-service training was 3.94.

In the area of sustainable agriculture, the items received high ratings (Table 36). All the items in this category had means over 4.00.

Table 36. Means, standard deviations and relative frequencies of individual items for ratings of sustainable agriculture competency areas in the North Central region based on high school agricultural instructors willingness to expand instruction in biotechnology if provided inservice education (N=325).

Competencies	Mean [a]	S.D.	% 1	% 2	% 3	% 4	% 5
Describe the importance of soil organic matter.	4.28	0.70	0.9	0.6	6.6	53.2	38.6
Explain the use of natural enemies in the management of insects, diseases, and weeds.	4.26	0.70	0.9	0.3	8.2	53.0	37.5
Gain knowledge in the use of resistance in management of diseases, insects, and weeds.	4.23	0.68	0.3	0.3	11.4	51.6	36.4
Explain the biological properties of soil.	4.20	0.71	0.9	0.6	9.7	55.0	33.6
Describe the process of gene enhancement in the production of varieties suitable for specific environments.	4.00	0.78	0.9	2.2	18.2	53.5	25.2
Composite Mean	4.19						

[a]1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5= Strongly agree, S.D=Standard deviations.

The items with the highest means were (1) "to describe the importance of soil organic matter" with a mean of 4.28 and (2) "to explain the use of natural enemies in the management of insects diseases and weeds" had a mean of 4.26.

The statement with the lowest mean was "to describe the process of gene enhancement in the production of varieties suitable for a specific environment" with a mean of 4.00. In this category of competencies the overall mean ratings for the willingness of instructors to expand instruction in the area of sustainable agriculture was 4.19.

The area of environmental education had only three competencies. These three items were rated highly as all of them had means above 4.00 (Table 37). The statement with the highest mean in this category of competencies was "to describe the relationship between plants, animals and microorganisms within a particular ecosystem" with a mean of 4.11 The item with the lowest mean was "to understand how microorganisms can be useful in degrading wastes in the environment" with a mean of 4.06 (Table 37). The overall mean for the instructors' willingness to expand instruction in environmental education was 4. 06

Table 37. Means, standard deviations and relative frequencies of individual items for ratings of environmental competency areas in the North Central region based on high school agricultural instructors' willingness to expand instruction in biotechnology if provided inservice education (N=325)

Competencies	Mean[a]	S.D.	% 1	% 2	% 3	% 4.	% 5
To describe the relationship between plants, animals, and microorganisms within a particular ecosystem.	4.11	0.75	0.6	2.2	12.4	54.3	30.5
To explain the enzymatic activity of bacteria in the decomposition of crop residues.	4.07	1.41	0.6	2.2	18.4	53.3	25.1
To understand how microorganisms can be useful in degrading wastes in the environment.	4.06	0.79	1.0	2.9	14.3	53.0	28.9
Composite Mean	4.06						

[a]1= Strongly disagree. 2 = Disagree 3= Neutral. 4=Agree. 5= Strongly agree. S.D = Standard deviation.

Comparative analysis of the various groups of respondents regarding their perceptions on selected bioscience /biotechnology competencies

The agricultural educators were compared on the basis of their gender (Table 38) on what categories of the seven areas of competencies of plant sciences, genetics, animal science, food science, microbiology, sustainable agriculture, and environmental education they perceived should be infused into the agricultural education curriculum. There was a significant difference between the genders in six of the seven categories of competencies namely, genetics, animal science, microbiology, food science sustainable agriculture and environmental education. The female respondents had higher means compared to the male respondents for composite means of the six categories of competency areas as shown in Table 38.

Table 38. Composite means, standard deviations and F-values of competency areas by gender

Competencies	Male (n= 261)		Female (n=59)		F- value[b]
	Mean[a]	S.D.	Mean	S.D.	
Plant Sciences (9)[1]	4.13	0.46	4.21	0.47	1.47
Genetics (13)	3.92	0.55	4.12	0.54	6.38*
Animal Science (4)	4.14	0.56	4.31	0.53	4.87*
Microbiology (8)	3.80	0.59	4.03	0.67	6.70*
Food Science (5)	3.88	0.62	4.22	0.59	14.7*
Sustainable Agriculture (5)	4.17	0.54	4.34	0.47	4.58
Environmental Education (3)	4.01	0.69	4.25	0.59	5.82*

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. [b] Equal variances assumed. $p \leq 0.05$

The composite competency in the area of plant science showed that there was no significant difference between the male and female respondents. However the mean for the female respondents was also higher at 4.21 while the male respondents had a mean of 4.13.

A comparison between educators who had/ or had not received pre-service training to determine if they held different perceptions regarding the role of bioscience / biotechnology in the agricultural education curriculum in the North Central region is shown in Table 39.

Table 39. Means and F- values of perceptions held by agricultural educators in the North Central region with /or without preservice training

Perceptions	Respondents		F-value [b]
	Preservice training[a] (n=166)	No Preservice training[a] (n=158)	
Infusion of sciences basic to biotechnology is essential for agricultural education in secondary schools.	4.20	4.06	2.58
Learning basic science chemistry, biology, physics and others better understand agricultural sciences.	4.32	4.22	2.31
Students should learn how to explain the processes that occur in plants and animals while learning biotechnology.	4.37	4.27	2.67
Infusion of more science into the agricultural education curriculum would expose students to diversified career opportunities in agriculture.	4.18	4.10	1.07
Learning about biotechnology helps students solve practical problems in agriculture.	3.93	3.84	1.31
Studying the sciences basic to agriculture helps students develop skills in related agriculture fields.	4.40	4.26	4.87*
The infusion of biotechnology requires modification of the agricultural education curriculum.	3.72	3.83	1.19
The Infusion of biotechnology requires more teacher in-service education.	4.26	4.23	0.10
The infusion of biotechnology increases student interest in studying agricultural education.	3.66	3.54	1.60
Students are interested in learning the basic sciences as they are related to agriculture.	3.60	3.61	0.02

Table 39 Continued.

I am interested in relating basic science skills and knowledge to agriculture	4.39	4.21	6.63*
Additional instructional materials are required for infusing biotechnology into the study of agriculture.	4.39	4.34	0.52
It takes additional time for teachers to incorporate biotechnology into the study of agriculture	4.21	4.15	0.42
The infusion of biotechnology into the agriculture curriculum strengthens FFA.	3.53	3.49	0.11
The infusion of biotechnology into agriculture helps develop meaningful supervised agricultural experience programs.	3.62	3.58	0.22

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree; [b] Equal variances assumed. * $p \leq 0.05$

The instructors showed a significant difference in only two perception statements 1) "Studying the sciences basic to agriculture helps students in develop skills in related agriculture fields". Instructors with preservice education in biotechnology had a mean of 4.40 and those without preservice had a mean of 4.26. 2) "I am interested in relating basic science skills and knowledge to agriculture". Instructors with pre-service training had a significantly higher mean of 4.39 compared to those who had no pre- service training with a mean of 4.21.

Instructors who had participated in some in-service program were compared to those who had not attended any in-service education to determine if there were any significant differences in the perceptions they held on the role of bioscience/biotechnology in the agriculture curriculum. (Table40). The instructors held significantly different perceptions for only one statement. This statement was "I am interested in relating basic science skills and knowledge to agriculture". Instructors who had in-service training had a higher mean 4.37 compared to those who had no in-service training with a mean of 4.19 (Table 40).

Table 40. Means and F-values of perceptions held by agricultural educators in the North Central Region with or without inservice training

Perceptions	Respondents		F-value[b]
	Inservice Training[a] (n=166)	No Inservice Training[a] (n=158)	
Infusion of sciences basic to biotechnology is essential for agricultural education in secondary schools.	4.18	4.07	1.37
Learning basic sciences chemistry, biology, physics and others helps students to better understand agricultural sciences.	4.28	4.26	0.02
Students should learn how to explain the processes that occur in plants and animals while learning biotechnology.	4.34	4.29	0.55
Infusion of more science into the agricultural education curriculum would expose students to diversified career opportunities in agriculture.	4.14	4.12	0.08
Learning about biotechnology helps students to solve practical problems in agriculture.	3.93	3.83	1.55
Studying the sciences basic to agriculture helps students develop skills in related agriculture fields.	4.35	4.29	0.78
The infusion of biotechnology requires modification of the agricultural education curriculum.	3.72	3.88	2.39
The infusion of biotechnology requires more teacher in-service education.	4.28	4.18	1.55
The infusion of biotechnology increases student interest in studying agricultural education.	3.68	3.49	3.60
Students are interested in learning the basic sciences as they are related to agriculture.	3.57	3.64	0.58
I am interested in relating basic science skills and knowledge to agriculture.	4.37	4.19	7.20*

Table 40.Continued.

It takes additional time for the teachers to incorporate biotechnology into the study of Agriculture.	4.17	4.20	0.10
Additional instructional materials are required for infusing biotechnology into the study of agriculture.	4.38	4.33	0.34
The infusion of biotechnology into the agriculture curriculum strengthens FFA.	3.46	3.59	1.55
The infusion of biotechnology into agriculture helps develop meaningful supervised agricultural experience programs.	3.59	3.61	0.03

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree: [b] Equal variances assumed. * $p \leq 0.05$ level

It is interesting to note that both the instructors with pre-service training and those with in-service training held significantly different perceptions on the same statement "I am interested in relating basic science skills and knowledge to the study of agriculture. Indicating that instructors perceived that relating the basic science skills and knowledge to agriculture was important to them in-order to integrate science into agriculture.

Summary of Open Comments

The open comments from the respondents are summarized into eight categories that the comments appeared to fit into Table 41. The most common comments related to the content of the agricultural education curriculum. Fifty respondents stressed the need to adapt the curriculum to suit the needs of not only the students but also the community in which they lived. Many of them believed that integrating more bioscience /biotechnology into the curriculum would attract more students to their programs. Fourteen respondents saw a need for inservice training for agriculture instructors to encourage them to integrate more science into their agriculture curriculum. Six instructors appreciated the timeliness of the topic of the survey and expressed a desire to obtain a summary of the findings of this study. Six instructors expressed a desire to obtain relevant additional instructional materials to integrate into their curriculum. Four participants were interested in infusing more science into their curriculum but believed that their schools did not have sufficient resources to effectively do this. Three respondents cited inadequate facilities in their schools as a possible limitation to infusing more science.

Table 41. Categories of open comments and number of respondents

	Category	Number of responses
1.	Comments related to the content of the agricultural education curriculum	50
2.	Inservice education	14
3.	Appreciating timeliness of topic of survey and desire to obtain summary of findings of this study	6
4	Additional Instructional materials	6
5.	Inadequate resources at high schools	4
6.	Inadequate facilities	3
7.	Preservice Training	2
8.	Time taken to prepare instructional materials for integrating More science into the curriculum	2
9	No need for inservice training	1
10	Categories of students interested in specific areas of agriculture	1

Two instructors believed that more teacher education programs should incorporate preservice training related to biotechnology for beginning teachers. Two instructors cited the amount of time needed to prepare ones' classes for integrating more science as one of the factors that discouraged teachers. One teacher believed that not all teachers needed inservice education. One teacher gave percentages of students interested in specific areas of agriculture.

Summary of Findings

The following statements summarized the major findings of this study.

1. The average age of the agricultural education instructors in the North Central Region of the U.S. was 40.7 years. The study found that the highest level of education attained by 57% of the instructors was a Bachelor of Science degree, whereas 41.2% had earned a Master of Science degree and only 1.2% had earned a Doctor of Philosophy degree. The average experience of the agricultural educators in the North Central Region was 15.1 years.
2. There were very few differences among teachers' perceptions based on demographic comparisons.
3. It was found that teachers who had received either preservice or inservice training tended to have a higher perception of the role of bioscience /biotechnology in agricultural education in the North Central region compared to respondents who had no preservice or inservice education in biotechnology.
4. Over half of the respondents had preservice education on biotechnology and over three fifths of the instructors had some inservice education in biotechnology.
5. The respondents agreed with all of the basic perception statements on biotechnology being infused into the agricultural education curriculum. On the basis of a 5 point scale where 5 was strongly agree, all items were rated 3.50 or higher
6. The respondents agreed most on the statement "Additional instructional materials are required for infusing biotechnology into the study of agriculture".
7. Respondents agreed least on the statement "The infusion of biotechnology into the agricultural education curriculum would strengthen the FFA".

8. The instructors mostly agreed that all the seven areas of competencies included in this study should be infused into the agriculture education curriculum. On the basis of a 5-point scale where 5 was strongly agree all items in five of the competency areas namely, plant science, genetics, animal science, sustainable agriculture and environmental education had composite means of 4.00 and above. However, they seemed not to totally agree that the competencies in microbiology and food science categories should be rated as highly as the others. These were the only two competency areas with composite means below 4.00.
9. The agricultural education instructors gave the highest ratings to the bioscience competencies in the sustainable agriculture category. Microbiology competencies had the lowest ratings.
10. The instructors perceived a need for inservice education in several areas but especially in sustainable agriculture and animal science.

CHAPTER V.

DISCUSSION

The primary purpose of this study was to identify the perceptions of secondary school instructors of agricultural education regarding the role of the biosciences and biotechnology in the agricultural education curriculum in the North Central region of the United States. The objectives of the study included identifying general perceptions about biotechnology education. The second objective of the study sought to determine the degree to which teachers perceive competencies in bioscience and biotechnology should be infused into the agriculture curriculum. A third objective of the study was to determine the extent to which competencies in biotechnology would be taught if additional materials and inservice training were provided to the teachers. Selected demographic factors were used to compare the responses of teachers in this study. An inservice training model was developed to describe how an inservice education program could be delivered focused on emerging technologies if deemed appropriate by state leaders in agricultural education.

The social reconstructionists' concepts of curriculum development advocates confronting the learners with severe problems facing the society. Optimistic social reconstructionists are convinced that education can affect social change and want a curriculum that challenges students' creative thought and helps them to look at alternate ways of solving the world's problems (McNeil 1996). A problem of major concern both on a global and national level is the conservation of natural resources and protection of the environment. Agriculture is a major contributor to soil erosion and non-point sources of pollution of ground water. Modern intensive farming methods cannot be sustained at current production levels. Some people have suggested a "revolutionary approach under the banner of low –input sustainable agriculture combined with technologies such as biotechnology rather than the current production systems may be the hope for the future of agriculture.

Barrick was of the view that a new vision for agricultural production in the 1990's was conservation of the environment.

The need for the agricultural education curriculum to address the issues of environmental conservation and integrating more science into the curriculum has been identified by various studies. McNeil (1996) contends that the interests of America lie in providing students with a curriculum that is fixed on the future and what is possible and potential.

Educators in agricultural education continually ask the question of how to respond to both the need for the curriculum to address the natural resources conservation issues and the needs of the students who must be prepared for the technological careers of tomorrow. More investment in the education system is needed to develop students who are not only competent in agricultural education but can also deal with complex situations and changing technologies such as biotechnology. Studies addressing the integration of science into the agriculture curriculum have shown that it is beneficial to the students and prepares them for diverse careers in agriculture. Moss (1989) recommended that competencies in agriscience and emerging occupations and technologies should be identified and these should form the basis for updating agricultural education programs. Roegge and Russell (1990) found that integrating science and agriculture was beneficial to the students because it produced higher overall achievement in the sciences and stimulated student interest in agricultural education.

Following the social reconstructionists' concept of curriculum development this study sought to address the need of the agricultural education curriculum in secondary schools to change to keep up with the needs of the students and the society. This study focused on identifying the role of the bioscience / biotechnology in the agriculture curriculum as perceived by the agricultural educators at the secondary school level.

The agricultural education instructors in secondary schools in the twelve states of the North Central region served as the target population of this study. The target population consisted of 2,429 agricultural education instructors. A sample of 610 agricultural educators was selected for this study. This chapter presents a discussion of the major findings of the study. The discussion is presented under the following topics based on the objectives of the study. These topics are (1) demographic information, (2) general perceptions regarding the role of bioscience /biotechnology in agricultural education, (3) competencies instructors perceived should be infused into the curriculum, (4) willingness to expand the teaching of selected competencies given additional materials and inservice training, and 5) description of an inservice training model that would be beneficial to agricultural educators.

Demographic Information

Most (81.4%) of the agricultural education instructors in this study were males. There were only 60 females in the study. The average age of the instructors was 40.7 years. This indicates that the agricultural instructors in the North Central region were a group of middle-aged people. The mean experience of the agricultural education instructors was 15.1 years. This data indicates that most of the respondents in this study were very experienced in teaching agricultural education. Rogers (1983) believed that age could play an important role in the adoption of agricultural practices for farmers. Perhaps the agricultural education instructors followed a similar pattern. The agricultural instructors in this study were experienced teachers although they had favorable perceptions of the role of bioscience/ biotechnology they were hesitant to integrate biotechnology into their agriculture curriculum. Slightly over a half of the instructors had some pre-service training in biotechnology. This indicated that nearly half the instructors were not well prepared to integrate bioscience into their curriculum as beginning teachers. More than half, of the instructors had received some kind of in-service education in bioscience /biotechnology this indicated that many of the instructors were willing to become more prepared in integrating bioscience /biotechnology. However this finding was surprising because many of the teachers believed that they were not well prepared to integrate science into their curriculum therefore one would have expected the number of those attending inservice training to be higher. Slightly over half of the instructors had a Bachelors degree. The distribution based on the levels of education indicated that the sample consisted of a group that could benefit from a graduate level course in biotechnology.

General Perceptions

The first objective of this study was to identify the general perceptions held by the agricultural education instructors about the role of bioscience /biotechnology in agricultural education. Overall, the agricultural educators held favorable perceptions on the role of bioscience /biotechnology in agricultural education. Out of the 15 statements, 9 had means above 4.00 with only 6 statements with means below 4.00. This indicated that the teachers believed that integrating more science into their curriculum would be beneficial to the students. A similar study conducted by Rajasekeran (1988) but national in scope found that the instructors had positive perceptions regarding the role of bioscience / biotechnology in the secondary school agriculture curriculum. This finding concurs with those of Rudd and Hillson (1995) in a study of agricultural programs in middle schools in Virginia who found that instructors' perceptions of an agriscience curriculum was a moderate predictor of the amount of agrisccience that could be adopted in these programs. Orton (1996) was also of the opinion that teacher beliefs play an important part on what teachers teach and this in turn affects students learning. Newman and Johnson (1994) on the other hand found that although teacher perceptions towards the agriscience curriculum were favorable other factors affected their adoption of the curriculum.

Although teachers had favorable perceptions toward the infusion of more biotechnology in the agriculture curriculum, perceptions that could be seen to directly benefit students such as FFA and SAE received lower ratings compared to the other perception statements. This indicates that the instructors saw FFA and SAE as integral parts of the agriculture programs but did not see how they could use them to enhance their bioscience / biotechnology curriculum. These findings concur with those of Camp, Clark and Fallon (2000) who concluded that although the SAE remained an important component of the agricultural education curriculum many, educators did not support it in practice. Many of the educators who participated in the Camp, Clark, and Fallon study believed that SAE needed to be redefined and broadened to reflect the realities facing the educators today. Steele, (1997) in a study in New York, also found that educators supported SAE in theory but in practice the quality and quantity of the programs had declined. With regards to FFA, although the findings indicate that the instructors tended to agree that integrating more science into the curriculum would strengthen FFA, it received the lowest rating of the perception statements. This finding concurs with the study conducted by Croom and Flowers (2001) that indicated that agricultural educators had a primary responsibility of ensuring that FFA is an important and functional part of the agricultural education curriculum.

Bioscience /Biotechnology Competencies

A second objective of this study was to determine the degree to which teachers perceive the competencies in bioscience and biotechnology should be infused into the agricultural education curriculum. The agricultural educators perceived the need to infuse more plant science into the agriculture curriculum. The instructors tended to agree with most of the selected items in this category. Instructors perceived significant practical value of some of the items that were included in this competency area such as hormones promoting plant growth and propagation of plants. This finding concurs with those of Rajasekeran (1988) who found that agricultural educators perceived competencies in this category to be important to the agriculture curriculum at the secondary school level.

In the area of genetics, instructors perceived the need to infuse items that related to traditional plant breeding than those which were related to cell biology. It would appear that most competencies, involving cell biology, which is the center of biotechnology, were not considered important to the agricultural education curriculum by most of the instructors. The study conducted by Rajasekeran (1988) found that educators rated competencies in this category low and tended to rate all competency areas relating to cell biology low. Wilson, Kirby, and Flowers (2002) found that, although the instructors perceived the need for biotechnology instruction, they believed they lacked the knowledge to adopt this new curriculum. It is also possible that the instructors may have assumed that knowledge at the cellular level was taught to the students in the science curriculum. However, agriculture provides a unique setting for students to see science in practice and how it is practiced in the real world.

Competencies in animal science were rated quite high. The instructors agreed with all of the items in this category. The competencies included in this category had practical significance to animal production. Therefore, it was easier for the instructors to see the practical value of these competencies. This finding is supported by Thomas and Groves (1986), who stated that teaching livestock production to agriculture students was traditionally a major part of the vocational agricultural program and instructors felt confident to teach the skills that they were confident they could perform. Rajasekeran (1988) also found that educators tended to agree that competencies in animal science were important to the agricultural education curriculum. However the educators in the Rajasekeran (1988) study rated the competencies lower than those educators who took part in this study.

In the area of microbiology and food science, the instructors tended to rate competencies lower than the other categories. In microbiology, the instructors did not perceive the need to infuse competencies related to the cell structure of microorganisms. This information may suggest that a lack of adequate laboratory facilities, equipment, and instructional materials could be a reason for a lower desire to teach in this area. Educators who participated in the Rajasekeran (1988) study rated the competencies in the area of microbiology and food science quite low.

The moderate ratings of competencies in microbiology could suggest that the teachers perceived the need for the students to have some knowledge and awareness of the different types of microorganisms. However, they may not have considered detailed knowledge of the structure of microorganisms necessary for the students to understand the role of these organisms in agriculture. In the area of food science, as well, the teachers perceived the general principles involved in food processing such as fermentation and microbial activity in milk to form diverse milk products to be important. However, the instructors did not perceive knowledge of specific microorganisms and identification of some of the products of food processing through biotechnology to be important for the students.

In the area of sustainable agriculture, the items were rated high. The instructors perceived the need for infusion of these competencies. This indicates that the instructors were aware of the increasingly important need for agriculture to become a more sustainable enterprise and the importance of the need for the students to acquire these competencies. The instructors may also have perceived this category of competencies as necessary because they could foresee their practical value to agriculture. Sustainable agriculture also provided the instructors a unique opportunity to show their students the connection between science and agriculture. Kimball (2000) found through the FARMS program that science integration into agriculture was made feasible through practice.

Instructors perceived the need for infusion of environmental education competencies into the agriculture curriculum. All the items in this category of competencies were rated high. These findings indicated that the instructors were aware of the need for their students to understand concepts of environmental conservation in the context of agriculture. In this category of competencies, as in the case of sustainable agriculture, the teachers perceived the practical value of these competencies. Rolings and Wagemaker (1998) emphasized the need for environmental education in agriculture. as environmental degradation through agricultural activities is a human action that cannot be addressed only through technical solutions.

Expansion of Instruction in Bioscience /Biotechnology

The third objective of this study was to determine the extent to which agricultural education instructors would increase instruction in bioscience /biotechnology given additional materials and inservice training.

In the area of plant science, the instructors were willing to expand instruction in all competency areas because apparently they were related to plant growth and development that had visible practical significance. The instructors seemed less willing to expand instruction related to competencies they did not perceive to be of practical use.

The instructors seemed willing to expand instruction in the area of genetics. However, the instructors seemed less willing to expand instruction in the biological sciences at the cell biology level. This finding indicates that the instructors may not have been aware expanding instruction at the cell biology level was essential for students to understand modern techniques in plant breeding using biotechnology. For instance, teaching students about gene splicing without the students understanding the function of DNA would be a futile exercise. Current developments in biotechnology cannot be understood by agricultural education students unless they are taught the fundamental principles of biology (Martin, 1988). McCormick and Cox (1988) also supported the idea of giving students a strong background in bioscience before teaching the specifics in agribusiness and technology. Perry (1989) gave an example that illustrated how high school students through cloning plants from single cells and experimenting with propagation of pineapples and gooseberry plants in the laboratory could understand the structure and function of DNA in a cell. It could also be concluded that the instructors were interested in teaching biotechnology but were not very knowledgeable about how the principles of cell biology are essential to understanding biotechnology.

In the area of animal science, the instructors showed a willingness to expand instruction given additional materials and inservice training. It is possible that these competencies received high ratings because they were perceived as having practical importance. Animal science also provided a unique opportunity for instructors to explain biological principles by using some of the new innovative technologies in biological research. For example, the production of hormones that are being used to increase milk production in cattle and increase body weight in swine without increasing the animals' feed intake. It would appear that the instructors were interested in infusing application aspects of biotechnology into the animal science category.

The instructors seemed less willing to expand instruction in the area of microbiology competencies. Most of the competencies in this category received lower ratings than any other area. However, the instructors showed a willingness to expand instruction in items that had practical significance to agriculture. For instance, the instructors could see the practical significance for the students being able to identify the nitrogen-fixing organisms and explaining the process. The instructors also saw the practical significance of students learning more about beneficial microbes in agriculture. However, the instructors did not see the need to expand instruction to enable the students to gain knowledge and skills to recognize some of the microorganisms such as bacterial cells under the microscope. Wilson, Kirby, and Flowers (2002) found that instructors in North Carolina were in favor of teaching a special course in biotechnology and agriscience research, but believed they lacked the knowledge to teach the course.

In the area of food science the instructors were willing to expand instruction in processes that they perceived as of practical importance. Therefore, food processing, fermentation, and formation of new food products generated the interest of instructors as areas of expansion, given additional materials and inservice training. A needs assessment for community food preservation projects conducted as early as 1982, in Louisiana, supports this finding (Kotrlick and Garland. 1982). This study concluded that food processing should be included in every high school vocational agriculture curriculum.

The competencies related to microbial processes necessary in the preparation of food and post-harvest losses received less attention from the instructors. This could be attributed to the fact that the instructors may not have perceived the need for students to learn details of food processing although they have an important role in processes such as brewing. baking. sausage manufacturing. fermentation of vegetable materials such as saukeraut. pickles. and the manufacturing of fermented dairy products. The instructors may not have been aware of the fact that post-harvest losses due to microorganisms can be significantly high. Hulse (1995) contends that even if the use of pesticides is reduced because of the detrimental effects to the environment. other means will have to be used to reduce crop losses caused by microorganisms and insects in the field and post-harvest.

The instructors were willing to expand instruction in sustainable agriculture. The results of this finding showed that the educators were not only aware. but also perceived the need to infuse sustainable agriculture issues into the agriculture curriculum. In addition. this investigator believed that the issues of sustainable agriculture are diverse enough to provide opportunities for practical discussions in the basic sciences within the context of agriculture in the real world.

In the area of environmental education the instructors were willing to expand instruction to help students understand the relationship between plants. animals. and microorganisms in a particular ecosystem. The instructors were also willing to expand instruction to help students understand the role of microorganisms in the composition of crop residues and in degrading wastes in the environment. It would appear that the instructors perceived this as an area where there was a need to expand instruction to help students understand how agricultural activities can affect the environment. This finding concurs with those of Osborne and Dyer (2000) who found that both students and their parents saw the need for environmental education in agriculture but did not seem to understand how agriculture contributed to environmental degradation.

Open Comments

Though only a few of the respondents reacted to the open comment section of the survey, certain useful conclusions were drawn from them. Most of the instructors had positive comments about the survey, in general. Some instructors believed that the timing of the topic of the survey was appropriate, but many thought many more instructors would have responded had the survey been sent out in the early Fall.

Some of the instructors in Illinois believed that the agricultural education curriculum needed to teach skills that would help family farms continue and not just jump on the "corporate food production bandwagon". The instructors also believed that science should enhance the existing curriculum and not replace subject areas. Most of the instructors were quite positive about the need for infusion of more science into the agriculture curriculum. However, others believed that more science may make agricultural education too technical and most agricultural education departments are not well-equipped and do not have the proper facilities to teach most of the competencies listed in the questionnaire.

Some of the instructors believed they needed to learn how to integrate biosciences /biotechnology into their curriculum because they had the best opportunity for presenting the information in a commercial-free, unbiased way to the students. However, many of the instructors did not feel competent to teach students some of competencies listed in the survey. The instructors need information about biosciences /biotechnology and they also need instructional materials to enhance their curriculum and instruction on the best way to teach these concepts at lower levels. The instructors also believed that integrating science into agriculture would take too much time and the teachers are already inundated with responsibilities within and outside the classroom. Instructors already feel that they are not paid enough for the amount of work they do; therefore, if they are mandated to teach more science in agriculture, some programs may lose more than just young people.

Some instructors, despite having attended some inservice training programs, still did not feel competent to teach bioscience /biotechnology. Many believed that the workshops should be more hands-on and realistic to the situations in the secondary school classroom. The instructors also believed that it would be more beneficial for them to have readily available information on bioscience/ biotechnology for both students to learn and teachers to present. Therefore, many instructors believed there was a need for additional resources for equipment, facilities, and instructional materials for them to integrate more science into their curriculum.

Some instructors believed that the competencies required in the survey were above the academic level of most of their students and thought that infusing more science into the curriculum would only discourage those who were traditionally attracted to agriculture programs. These views are contrary to Perry (1989), who found that integrating more science into agriculture served to motivate students from low income groups and those who were potential school drop outs. Studies conducted by Caine and Caine (1991) further support the need for integration of science into agriculture because studies based on neural studies on the human brain found that various disciplines relate to each other and share common information that the brain can recognize and organize.

Other instructors believed that high school agriculture is merely an exploratory program and is not intended to train students to be future molecular biologists or scientists. This researcher agrees with this view, but believes the way agriculture is presented to students could be instrumental in helping students choose or not choose careers in agriculture. A study conducted with students taking biology and agriculture in high schools in Illinois, Iowa, Minnesota and Wisconsin to determine their college major, showed that most of the students were interested in horticulture because of the entrepreneurial opportunities available in the field. however. there was less interest in crop science. soil science biotechnology breeding and genetics (Compton. 2002). Instructors could do more to stimulate the interest of students in careers in agriculture by exposing them to the diverse options available to them. Some instructors also believed these topics in bioscience /biotechnology were good as advanced level work in secondary school or better still at the college level. This researcher believes that providing a good basic science foundation would be beneficial to students who were either employment bound or college bound.

Instructors in Minnesota believed this survey was a good introduction to bioscience /biotechnology in agriculture and hoped there would be more studies in the future. They believed it was an excellent survey and will help teachers and their students understand the role of biotechnology in agriculture. This researcher shares these views that understanding the basic sciences will help more people understand the role of biotechnology in agriculture and help them appreciate the benefits and the potential harmful effects as with any new technology.

Instructors in Ohio believed that some areas of the country would be able to incorporate more biotechnology than other areas. Instructors in Nebraska concurred with this view. as they believed that teachers in Iowa were ahead of them in integrating bioscience into their agriculture curnculum. Despite this. some teachers in Iowa still believed that it was not easy for them to integrate the sciences into their curriculum and many believed they were not knowledgeable enough to teach some of these competencies. However. they were integrating more science into their curriculum and thought Iowa State University was always willing to help them with any projects on biotechnology.

Instructors in Missouri believed they needed more quality training in bioscience /biotechnology before they could integrate the sciences into their curriculum. These instructors also believed their curriculum was already packed with items they believed the students needed to learn and wondered where they would fit bioscience. This investigator believed that critics of vocational agricultural education programs might have been referring to these types of programs where many things were taught and considered important but the science of agriculture received very little attention.

Some instructors were discouraged from integrating more science into the curriculum because their students were not able to receive science credit for their agriscience courses. However, in terms of program success, some instructors found that students were eager to join programs that were using emerging technologies such as biotechnology. In such programs, even instructors who were nearing retirement were interested in incorporating these concepts to strengthen their programs. In such instances the instructors overcame some of their existing barriers by pooling resources and by team teaching biotechnology courses with science instructors in their schools.

Some instructors believed that the instructors needed to change their curriculum to adapt to the changing needs of employers, students, and the society, in general. Terry et.al. (1992) in a study conducted in Texas to implement programs for agricultural literacy found that the enrollment of U.S. high school students in agriculture-related classes was only 4.5%. One of the instructors commented "we need to change the face of agriculture as society and industry changes in order to compete in public education". This researcher concurs because instructors present the information to the students in a non-biased way without trying to influence them. Even if students do not choose careers in agriculture, a public that understands the science of agriculture will be more likely to make informed choices about bioengineered foods and related issues.

Description of a Possible Inservice Training Model

Based on findings of this study, open comments from educators and the review of literature, an inservice training model for agricultural educators in secondary schools was described. The model is found in Figure 5.

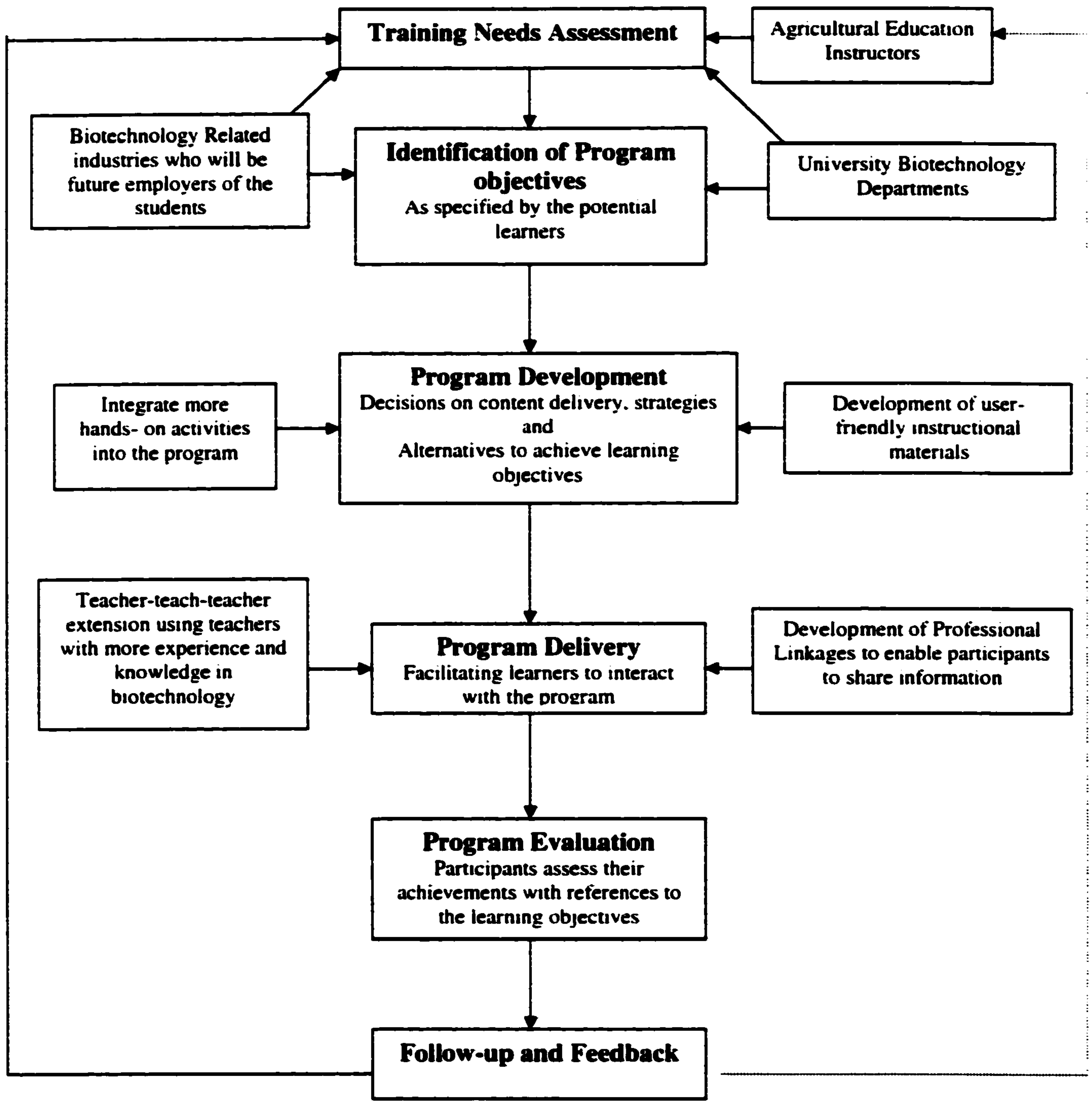

Figure 5. A model for inservice education for agricultural education instructors to integrate bioscience/ biotechnology into the agriculture curriculum.

The model sought to include most entities involved in biotechnology and not just the universities because the different groups have an impact on teachers' perceptions either directly or indirectly.

Needs Assessment

The findings support a need for an in-service training program for agricultural education instructors. The instructors expressed a need not only for up-to-date information on biotechnology, but also a need to learn a method of teaching some of the complex concepts in bioscience /biotechnology at lower levels. Therefore, the first step would be to conduct a needs assessment with the agricultural educators and university departments, that would be conducting this inservice training. The needs assessment would determine the areas instructors really need help. Rather than just using a direct needs assessment to collect the data several researchers have suggested using the Borich model (Barrick etal. 1983, Newman and Johnson, 1994, and Waters and Haskell, 1989). The Borich model is based on the discrepancy score derived from a respondent-determined level of importance and level of performance for specific competencies being assessed (Borich, 1980). This model would give a more accurate assessment of areas where the teachers need the most help because it gives scores on a combination of factors. The next step would be to identify the objectives of a program as specified by the agricultural instructors.

Program Development

Inservice training programs should be developed based on the needs of the instructors of agricultural education. The programs should be developed in specific areas, since bioscience /biotechnology is so diverse some teachers may need training in certain areas while others may not. This study revealed barriers to instructors infusing more science into their curriculum. These barriers were 1) the additional time it takes to integrate the science into their curriculum, 2) insufficient knowledge in some competency areas hence, instructors did not feel competent to integrate the sciences, and 3) lack of appropriate instructional materials, facilities, and equipment. For instance, instructors believed that updated information on biotechnology for them and some instructional materials they could readily incorporate into the existing curriculum would be helpful and save them some time. Instructors also believed that the workshops should be more hands-on and high school realistic to be beneficial to them. The instructors thought that workshops that used examples where agriculture and science were integrated and demonstrated in context would be helpful. Instructors found it difficult to integrate science into agriculture because they were taught differently. It was difficult for the instructors to see the connections between them when they teach because they lack a contextual learning theoretical base (Thompson and Balsweid, 2000). During the program development stage, the instructional materials should be developed for the instructors. These materials should not only be materials that are useful for the instructors own learning, but also materials they can readily use to enhance their delivery in the classroom. Therefore, the instructional materials should focus on the subject matter as well as the educational process. Conducting and planning workshops that include science and agriculture instructors from the same school district would also be helpful to encourage cooperation between the teachers in the two areas. Some schools already have successful programs that are team taught by science and agriculture teachers.

Program Delivery

Following the social reconstructionist theoretical base requires that the learning opportunities be (1) real (2) require action and (3) must teach values. The instructors in this study believed they needed updated information on biotechnology, but were also in need of a more hands-on experience to help them demonstrate how science is connected to agriculture. Therefore, programs, with several opportunities for hands-on experience in bioscience

/biotechnology in agriculture would be beneficial to the instructors. Using activities where instructors are able to learn from other instructors who have been successful at integrating agriscience programs would also encourage more teachers to integrate science into their agriculture curriculum.

The social reconstructionist theory for curriculum development encourages use of community resources to supplement the school curriculum. Therefore, encouraging agricultural educators to use various resources within their communities such as encouraging participants to develop professional linkages with their peers would be beneficial to them for professional development and in developing better agriscience programs. Developing linkages with industries and other entities would also be helpful for instructors in placement of their students for supervised agricultural experiences. Linkages with industries may help to provide equipment and resources to schools. Therefore, during the program delivery process, it is important to help participants establish professional linkages that will enable them to share experiences, knowledge, and information.

Program Evaluation

It is important that program evaluation be conducted to assess the impact of the professional development program. During the evaluation process, participants of the programs are reminded of the original educational learning objectives of their specific program. The evaluation should be designed in a way that helps the participants assess their own learning achievements within the context of the educational objectives of the program. It is also important that university departments that conduct the programs identify the problems and suggestions related to the programs, in order to improve the learning process and to further the goal of infusing more science into the agriculture curriculum.

Follow-up and Feedback

Evaluation of the findings should be used to conduct follow-up and to request feedback especially with participants who may be unhappy with the programs, to try to overcome the problems or resolve the issues and concerns. Follow-up of the participants should also be conducted in the field to find out how successful they have been in the process of integrating more bioscience/ biotechnology in the curriculum. The follow-up and feedback information should be incorporated into a needs assessment process for future development and program planning.

Summary

This study had several implications for teacher education programs and future inservice needs of secondary school agricultural education instructors.

1. The average age of the instructors was 40.7 years. This implies this was a group of experienced instructors with several years teaching experience. However, this also means that many of these instructors were trained when biotechnology research was just beginning in agriculture and also explains why many of them did not feel competent enough to integrate bioscience /biotechnology into their curriculum.
2. Overall, the instructors had favorable perceptions about the role of biotechnology in the secondary school agricultural education curriculum in the North Central Region. This implied they were willing to integrate bioscience /biotechnology into the agriculture curriculum.
3. Many of the teachers in this study indicated they needed inservice training appropriate to their needs. This implied that some of them had attended in-service training but they did not think it was very beneficial to them. Not all the instructors had made use of existing inservice training opportunities despite the fact that many of them believed they were in need of training.

4. Many teachers were interested in integrating more bioscience /biotechnology into their programs, but many believed they had several barriers preventing them from doing so. The instructors believed they needed additional instructional materials, time, facilities, and equipment to effectively integrate bioscience /biotechnology into the agriculture program. They believed their lack of commitment to integrating biotechnology into in their agriculture curriculum was due to constraints that were sometimes beyond their control.
5. The instructors' perceptions of bioscience tended to be high in areas where they could see the practical significance such as plant growth and production, animal production, sustainable agriculture, environmental education, areas of traditional plant breeding and food processing. This implied that the instructors might have rated areas of cell biology low because they were not very knowledgeable in these areas.
6. The instructors' did not appear to be interested in expanding instruction in the areas of cell biology, function of microorganisms, and microbial processes in food. This implied that many of the teachers were not well informed about these areas which implies that they were not very knowledgeable about the fundamental principles of biotechnology and their impact on agriculture. The instructors implied that their lack of enthusiasm was due to the fact that they had inadequate laboratory facilities to effectively change their programs.

Chapter VI

Summary, Conclusions, Recommendations and Implications

Summary

Bioscience is a systematic study of the principles and concepts applied to the functions and problems of living organisms; whereas, biotechnology is described as any technique that uses living organisms, parts of living organisms, or their products for commercial purposes. Biotechnology with all its complexities and challenges has and promises to revolutionize agriculture (Lappe and Bailey, 1998). Johnson (1999) has rightly contended that the twenty-first century could be known as the "Century of Biology" because of the phenomenal magnitude of developments in biotechnology.

According to Schor (1994), plant biotechnology offers the greatest potential because the seed, the medium containing vital genetic information, is of primary importance to biotechnological research. So phenomenal is the transformation of agriculture by biotechnology that leading chemical firms and others have developed an inordinate interest in biotechnology giving a secondary focus on their main enterprise of producing chemicals (Lappe and Bailey, 1998). This change in focus by renowned chemical firms has caused the American Chemical Society (1997) to wonder who will make chemicals if all firms are conducting research and developing biotechnology products. With these changes in industry and agriculture, in general, it is important that agricultural instructors are aware of these changes and prepare their students for employment in areas of these emerging technologies. Biotechnology could provide employment to students of varying aptitudes. The proponents of biotechnology tout this technology and see biotechnology as a solution to the world's food problems.

However, biotechnology, like all new technologies, is not without its critics. Lappe and Bailey (1998) are skeptical about the potential of biotechnology to solve the world's food problems. They contend that to date biotechnology has been used in a number of innovations that have produced agricultural products which are more user-friendly, but very few have genuinely increased productivity. Duffy (2001) concurs with this view. He has stated, "Evidence shows that it is not the hungry who are being fed by biotechnology but rather the affluent, i.e., those who can afford to buy the food". He further contends that the problem of hunger is distribution and politics. On a more global forum, Hamilton (2000), on the other hand, is in favor of integrating all aspects of agricultural science, technology, and public service into youth programs and believes this has greater potential to solve the world's food problems than biotechnology alone.

Some of the instructors in this study also believed that biotechnology is a technology focused on corporate farms and indicated agricultural education teachers should not abandon teaching their students how family farms can survive. These opposing views of biotechnology make it necessary for instructors to understand the technology and its role in the agriculture curriculum. Instructors are in a unique position to present information about biotechnology and agriculture to their students in an unbiased form without influencing student decisions regarding the technology. This learning will help students make informed choices about their careers and form their own views on biotechnology in agriculture.

This information formed the basis for some of the key questions in this study. They are

1. What are the perceptions of agricultural instructors regarding biotechnology in agriculture?
2. To what extent should selected bioscience/biotechnology competencies be infused into the agricultural education curriculum?
3. What inservice education is needed to help teachers infuse bioscience / biotechnology into the curriculum?
4. How do teachers differ in their perceptions regarding bioscience / biotechnology?

The purpose of this study was to identify perceptions of secondary school instructors of agriculture regarding the role of bioscience / biotechnology in the agriculture curriculum of the North Central Region of the United States. This study sought to determine the degree to which teachers perceived competencies in bioscience /biotechnology could be infused into the agriculture curriculum.

The specific objectives of the study were:

1. To identify the perceptions of secondary school agricultural educators regarding the infusion of bioscience /biotechnology into the agricultural education curriculum in the North Central region of the U.S.A.
2. To identify the extent to which selected science competencies appropriate to biotechnology should be infused into the agricultural education curriculum.
3. To determine the degree to which bioscience /biotechnology competencies would be taught if inservice education and instructional materials on biotechnology were provided to the teachers, and
4. To determine what differences existed between the teachers when grouped by demographic factors.
5. To describe an inservice training model for a program that would focus on integrating the sciences into agriculture.

The population of the study comprised of 2,429 secondary school educators in the North Central Region of the United States. A stratified random sample of 610 secondary school agricultural educators was selected from the population. There was a 53.3% return rate for the mailed questionnaires. Findings of this study were based on 325 completed questionnaires.

The information was collected from the teachers through a mailed questionnaire. There were four main sections in the instrument related to the specific objectives of the study. Validity and reliability of the instrument were established by conducting a pilot study with a subset of the secondary school agricultural educators. The Cronbach's reliability coefficient for the instrument ranged from 0.57 to 0.95, showing that most of the items on the instrument were adequately reliable for this study.

The SPSS computer package was used to analyze the data; means, standard deviations, and correlation analysis were performed in order to meet the objectives of this study.

Demographic data revealed that 80.1% of the respondents were male. The respondents' mean age was 40.7 years. The average number of years of experience as secondary school instructors in agriculture was 15.1 years. The majority of the instructors had a bachelors' degree as the highest degree and only a few instructors had a Ph.D.

The secondary school agricultural educators' perceptions regarding the role of biotechnology in the agriculture curriculum were obtained by using a 15-item instrument. A factor analysis of the perception statements to further establish the construct validity of the instrument showed three main factors: 1) biotechnology, 2) knowledge and skills based items, and 3) questions pertaining to agricultural education used to identify the perceptions of instructors regarding the role of biotechnology in agriculture.

Responses to the perception statements were mainly positive. Nine of the items on the instrument had a rating above 4.00, while six of them had ratings below 4.00. The responses of these statements were obtained on a five-point Likert type scale ranging from 1=strongly disagree to 5=strongly agree.

Overall, instructors' perceptions of the competencies in bioscience /biotechnology were positive. The instructors saw a need to infuse more sustainable agriculture and plant science competencies in the agricultural education curriculum. Instructors perceived a need to moderately infuse animal science, environmental education, and genetics into their curriculum. Food science and microbiology knowledge skills were rated lower than the other competencies. When asked the degree to which instructors would be willing to infuse bioscience /biotechnology into agriculture, instructors seemed to agree that competencies in animal science and sustainable agriculture should be expanded significantly, followed by plant science and environmental education. Genetics and food science could be expanded moderately. Microbiology received the lowest rating for the expansion of instruction. Instructors gave these competencies relatively less attention in terms of the need for expansion of instruction. The findings indicated that instructors were willing to expand instruction in traditional areas, which they believed would improve agricultural productivity.

Conclusions

The findings of this study led to the following conclusions.

1. The secondary school educators in the North Central Region of the United States were predominantly middle-aged. Most of the respondents had extensive experience as instructors. The instructors were predominantly male. A good number of the agricultural instructors had attended some form of inservice training in biotechnology.
2. The agricultural educators in secondary schools had a positive perception of the role of bioscience /biotechnology in the agriculture curriculum. The perceptions of the agricultural instructors did not vary significantly with age, years of teaching experience, level of education, or gender.
3. Several of the agricultural educators believed they required additional time to integrate more science into their agriculture curriculum. Other constraints to integrating science into the curriculum were lack of resources, facilities, and equipment.
4. Instructors who had attended some inservice or preservice training tended to have more positive perceptions on integrating more science into their agriculture curriculum.
5. Instructors believed that competencies in the areas of sustainable agriculture, environmental education and plant sciences were important to the agricultural education curriculum at the secondary school level.

6. Instructors seemed to agree that instruction in the area of sustainable agriculture and animal science needed to be expanded significantly.
7. It would appear that instructors supported expansion of instruction in areas that they perceived to be of practical importance to agriculture. Competencies that were related to cell biology, on which biotechnology is centered, were not considered as important as competencies that were of practical value to agriculture. The instructors seemed less willing to expand instruction in areas like genetics and food science that have been the basis of tremendous growth in biotechnological research and industry.

Recommendations

The following recommendations are based on the findings and conclusions of this study.

1. There are many expectations of teachers, but at the same time they are expected to maintain high educational standards in their curriculum. Departments of Agricultural Education, Teacher Education Programs and Biotechnology Departments should provide instructors with updated information that is not only useful for their own learning but also readily available for them to incorporate into their existing curriculum. Teacher educators in agriculture and biotechnology departments should help instructors to integrate more science into their curriculum.
2. Inservice educational programs should be designed on the basis of needs and interests of the instructors for them to have positive learning outcomes.
3. Teacher educators in agriculture should consider providing a contextual learning theoretical base for integrating science into agriculture, because instructors tended to be tradition-bound.
4. Teacher education programs should focus on courses that model and emphasize collaborative relationships between science and agriculture teachers.
5. Teacher education programs should consider establishing depository libraries and

guidelines for curriculum materials in bioscience and biotechnology that can be frequently updated because agricultural technology especially in biotechnology changes so rapidly.

6. Agriculture teachers through their professional associations or department of education should consider establishing a communication network to exchange ideas, materials and relevant information about their agriculture programs.

Recommendations for Further Research

1. Further research is needed to determine what the instructors are teaching as part of their agriscience curriculum.
2. A similar study should be conducted for students taking agriculture in secondary schools to identify their perceptions on the role of bioscience /biotechnology in agriculture.
3. Many instructors see time and availability of appropriate instructional materials as a constraint to integrating science into their agriculture curriculum. Studies should be conducted focused on distance education programs that could provide inservice training or graduate level courses on biotechnology to determine their effectiveness and appropriateness.

Implications and Educational Significance of the Study

The primary purpose of this study was to identify secondary school agricultural educators' perceptions regarding the role of bioscience /biotechnology in the agricultural education curriculum. The findings of this study can be generalized to secondary school agricultural educators in the North Central Region of the United States. The findings from this study may have implications for planning and delivery of programs for inservice training focused on bioscience /biotechnology. The findings may also have implications for curriculum development in Teacher Education Programs. When respondents were compared on the basis of age, there were no significant differences between the experienced teachers and younger teachers entering the profession. One might expect that the younger people just entering teaching would have been more exposed to biotechnology education and hence would have a higher perception regarding the role of bioscience/ biotechnology education in agriculture. The results showed that the group was homogenous in this area regardless of age. This indicates that the teacher education programs may not reflect the broader view of agriculture. Swortzel (1999) in a national study of preservice teacher education programs in agriculture found that most programs contained an insufficient number of hours in natural sciences that applies to the science of agriculture being taught in high school agricultural education programs. Swortzel (1999) further contended that the problem is further compounded by the criteria used for admission of preservice teachers into agricultural education programs, these are based on active involvement in FFA, 4-H and strong communication skills, rather than on a strong foundation in the sciences.

The results imply that the goal of teacher education should not only be to expose preservice teachers to modern technology but to help them perceive the patterns that connect the modern and the traditional. This type of knowledge will help teachers to prepare students to develop more meaningful knowledge that is critical in the 21st Century rather than preparing them to learn a specific technology like biotechnology.

The call for a change in the agricultural education curriculum in secondary schools has been heard from both academic and non-academic sources, but teachers are the only ones who can make this change a reality. Many teachers are willing to integrate more science into their agriculture curriculum, but believe they are not well prepared to do this because they feel they are not knowledgeable enough in these areas. Therefore, it is necessary to develop well-designed educational programs that will meet the needs and interests of the participants. This study gives some idea of the topics, that may be of interest to instructors. Perhaps programs for teacher education should start teaching some of these topics for new instructors. For teachers to integrate more science into their curriculum, they need to be exposed to a curriculum that emphasizes integration of science during their preservice teacher education programs.

The results of this study indicate that agricultural education, as a profession needs to expand the idea of learning and teaching. It is not sufficient for teachers to merely replace the traditional curriculum with the new that incorporates modern agriculture. Teachers need to build a framework that allows them to integrate more science into agriculture. This will allow them to integrate the more innovative aspects of agriculture into the existing curriculum. In this way teachers can help students to understand the larger pattern of agriculture which includes both traditional and modern aspects. Teachers also need to have a strong foundation in the science of agriculture. This will enable them to emphasize science when teaching their students. In this way teachers can help develop learners who can demonstrate a high level of basic competence in agricultural education as well as deal with complex situations and changing technologies such as biotechnology.

According to the literature review, integration of science into agriculture is needed to improve the academic content of the curriculum, to improve the image of the agriculture programs, and to increase the employment opportunities for students in these programs. Wirth (1992) was of the opinion that many students avoid taking basic science courses that are necessary foundations for studying agriculture at secondary school and higher education levels. Integrating science into agriculture may make science more meaningful and could help overcome this obstacle. This implies a need to define the degree and type of sciences that should be infused into the agriculture curriculum. It is important to help teachers develop a more science-based curriculum, but at the same time retain the experiential learning and leadership opportunities that have been strengths of the agricultural education program. Additionally, this study clearly supports the idea that positive perceptions on the role of bioscience /biotechnology in agriculture is a prerequisite for an instructor's willingness to integrate science into the curriculum. Therefore, it is important to provide teachers incentives encouraging them to integrate science into the agriculture curriculum.

REFERENCES

Agricultural Educators Directory (2000).Charles M. Henry Printing.Co., Greensburg, Pennslyvania.Sarah Henry, Editor

Allison, B. and Carrington, A. (1980). Implementing Environmental Education in the School Curriculum, Virginia Beach, Virginia: Virginia Beach City Public Schools.

Amberson, M. (1989). Re-orienting Agricultural Education towards a Free Market Model Emphasizing Economic Understanding. Journal of Agricultural Education, Vol.30 (1), 2-9.

American Chemical Society (1997) Chemical and Engineering Newsletter October 6th Issue

Anthan, G. (2000). Biotech Dispute ignores effect of pollination. Register Washington Bureau. Des Moines Register.com October 1st 2000 (Des Moines, Iowa)

Ary, D., Jacobs, L.C. and Razavieh, A. (1996). Introduction to Research in Education (5th Ed.) Texas: Harcourt Brace College Publishers.

Balschweid M.A. (2002) Teaching Biology Using Agriculture as the Context: Perceptions of High School Students Journal of Agricultural Education Vol. 43 (2), 56-67

Balschweid, M. and Thompson, G.(1999). Integrating Science in Agricultural Education: Attitudes of Indiana Agricultural Science and Business Teachers. In Proceedings of the 26th Annual National Agricultural Education Research Conference, Orlando, Florida

Barrick, R. K., Ladewig H. W., & Hedges, L. E. (1983) Development of a systematic approach to identifying technical inservice needs of teachers. The Journal of the American Association of Teacher Educators in Agriculture. Vol. 24 (1), 13-19.

Barrick, S. (1989). The 1990's. The decade of the Environment. The Bottom Line (Winter pp. 1-6)

Bentley, O. G. (1986). Role of Research in Agriculture .In J.J. Crowley (Ed.), Research for Tomorrow, Yearbook of Agriculture. (pp.2-11) Washington D.C. U.S.A.

Biotechnology Information Series (1993) Preprint 4/ 93 North Central Regional Extension Publication No. Bio-1Vol. 1 (P.18-19) Published by Iowa State University

Borlaug, N.(2000). World Food Prize Focuses on Genetically Modified Organisms (GMO's). Iowa State Daily, Iowa State University-Student Newspaper Friday October 13th 2000

Blum , A.(1996). Teaching and Learning in Agriculture. A guide for agricultural teachers. Rome: Food and Agriculture Organization of the United Nations.

Borich, G.D. (1980) A needs assessment model for conducting follow –up studies. The Journal of Teacher Education Vol. 31(3), 39-42

Buriak, P. (1989). Incorporating agriscience in agricultural mechanics. The Agricultural Education Magazine, Vol. 61(9), 18-22

Burton, D. (1989) Alternative Summer Strategies for Secondary Agriculture Programs The Agricultural Education Magazine Vol. 61(12) 9, 22-23

Brameld, T. (1956). Toward a Reconstructed Philosophy of Education. New York: Dryden.

Camp, W.. Clarke, G and.Fallon, M (2000). Revisiting Supervised Agricultural Experience. Journal of Agricultural Education Vol. 41(3), 13-22.

Caine, R. N. and Caine, G. (1991) Making connections: Teaching and the human brain. Menlo, CA: Addison – Wesley Publishing.

Committee on Agricultural Education in Secondary Schools Board on Agriculture (1988). Understanding Agriculture: New Directions for Education, Washington, D.C. National Academy Press.

Compton, M.E. (2002) Results of a Horticulture Survey Completed by Agriculture and Biology Students attending High School in Illinois, Iowa Minnesota and Wisconsin National Association of Colleges and Teachers of Agriculture Vol. 46 (1), 44-49

Croom, D.B. and Flowers, J.L. (2001). Factors influencing an Agricultural Education

Students's Perception of the FFA Organization. Journal of Agricultural Education Vol. 42 (2), 28-36.

Daly, H. (1996). Beyond Growth. Beacon Press, Boston.

Day, P.R. and Meagher, L. (1996) Overview Agricultural Biotechnology: Novel Products and New Partnerships National Agricultural Biotechnology (NABC) Report No. 8, Pp. 3-11

Dekker, J. (1991). Pesticides. In Sustainable agriculture and food security. Rep. To United Nations Conference on Environment and Development Rio. By ISCU Committee on the Appl. Of Science to Agriculture, Forestry and Aquaculture. ICSU Press, Paris.

Dik, D.W. (1986). Future role of Electronic Technology in Agricultural Research and Extension. In J.J. Crowley (Ed.) Research for Tomorrow, Yearbook of Agriculture: Washington, D.C. U.S.D.A.

Doubleday, O. (1996). Expectations of the Growers of Arable and Horticultural Crops. IN Biotechnologies in agriculture and food: Coming to the market: Proceedings of a Conference organized by the Center for Agricultural Strategy, held at the Royal Society...London... on 5th March 1996/ Eds. Marshal, B.J. and F.A. Miller, Reading [England] Center for Agricultural Strategy, University of Reading, 1996.

Duffy, M. (2001) Estimated Costs of Crop Production in Iowa, Iowa State University Extension Service, FM1712.

Duval, C. L. (1988). The Agriscience Movement. The Agricultural Education Magazine Vol. 60 (11), 18-21.

Farmland Trust (1989) Risks, challenges and opportunities: agricultural resources and growth in a changing Central Valley . Prepared by Farmland Trust San Francisco, California Farmland Trust

Fehr, W. (1989). Biotechnology and Sustainable Agriculture demonstrate ties at Iowa State University. The Ag Bioethics Forum, 1 (4) 2.

Ferguson, J. (1990). Inside U.S. Agriculture Today Ag. Consultant Vol. 46 (1), 12-17.

Forte, S. (1989). Agriscience Program in Secondary Schools. The Agricultural Education Magazine, Vol. 58 (9), 17-18.

Gardener J. (2000). Ecological Perspective In Visioning for Sustainable Agriculture: Beginning the Discussion. http://www.ag.iastate.edu /centers/leopold /visionpaper.html.

Gliessman S.R. (1998). Agroecology: Ecological processes in sustainable agriculture Chelsea, Michigan Ann Arbor Press.

Goldburg R., Rissler, J. Shand, H and.Hassebrook, C (1990) Biotechnology's Bitter Harvest . Herbicide Tolerant Crops and the Threat to Sustainable Agriculture A Report of the Biotechnology Working Group

Hamilton N. (2000). Two sides of Iowa agriculture. Des Moines Register October 25th 2000 (Des Moines, Iowa) pp.15A.

Harlander, S.K. & Garner, R.G. (1986). The Future of Biotechnology in food processing. Research for Tomorrow: Yearbook of Agriculture. Washington, D.C: USDA.

Harris, L. (1989). Towards 2000 Agriculture. Penn State Agriculture. Pennsylvania State University, University Park Pennsylvania, Vol. 52(3), 9-10.

Hatch, D. (1996). Building a Bridge of Understanding Crops. In Biotechnologies in agriculture and food: coming to the market: Proceedings of a Conference organized by the Center for Agricultural Strategy, held at the Royal Society...London... on 5th March 1996/ Eds. Marshal, B.J. and. Miller, F.A Reading, England Center for Agricultural Strategy, University of Reading, 1996.

Herdt, R.W. (1997) Agricultural Biotechnology in the 21st Century: Promises and Pitfalls IN National Agricultural Biotechnology Council (NABC) Report 9. Resource Management in Challenged Environments Pp..33-40

Hess, K. (1987). Biotechnology and Agriculture. Proceedings of the Annual Meeting for Rural Sociological Association, Blacksburg, Virginia.

Hillyer, G. (1999). In biotechnology we trust. Progressive Farmer Vol. 114 (10), 22-24

House Committee on Agriculture. (1984) Long- term Policy to Succeed the Agriculture and food Act of 1981 (Research, Extension and Teaching). Hearings before the Subcommittee on Departmental Operations Research and Foreign Agriculture of the Committee on Agriculture, House of Representative Ninety-eighth Congress, June 6, 7, 12 and 13, 1984.

Hulse J. H. (1995). Science, Agriculture and Food Security National Research Council (NRC) (Canada) Research Press Ottawa 1995.

Iowa State Daily (2000) World hunger an overview of genetically modified organisms (GMO's), Iowa StateUniversity –Student Newspaper Wednesday October 25th 2000

Iowa Technical Committee on Biotechnology (1987). Final Report State Board of Vocational Education, Des Moines Iowa.

Johnson P. (1999). The real message of the millennium. Reader's Digest December 1999 Pg. 62-66.

Jenitor (1989). Impact of bioscience skills on animal diseases. The National Future Farmers Vol. 34(5), 17-19.

Kam, G.A. (1984). Strategies for Developing an Awareness on Biotechnology for Mixed Ability Groups in Secondary Schools. Journal of Science and Mathematics Education in Southeast Asia Vol. 7(2), 38-39.

Kimball, M. (2000). Sustainable Agriculture Education in the New Millennium. Sustainable Agriculture Vol. 12 (1), 6-7.

Kirschenmann, F. (2000). Questions We Aren't Asking in Agriculture: Beginning the Journey Toward a New Vision http://www.leopold.iastate.edu/fredspeech.html.

Knight, J.D., R.E. Farrell, B. L. Harvey and J.J. Germida (1997) An Overview of Resource Management in Challenged Environments in National Agricultural Biotechnology Council (NABC) Report 9.Pp. 3-4

Kotrlik J.W. and Garland, T.S. (1982) "An Assessment of the need for school community food preservation centers in Louisiana , Staff Study . Department of Agricultural Education, Louisiana State University Baton, Rouge

Krantz, C. (2000). Activists protest at conference. Des Moines Register.com September 21st 2000 (Desmoines, Iowa).

Kreijcie, R.V. and Morgan, D.W. (1970). Determining sample size for research activities. Educational and Pyscological Measurement Vol. 30, 607-610.

Lappe, M. and Bailey, B.(1998). Against the Grain: Biotechnology and Corporate Takeover of Your Food.Common Courage Press, Monroe, Maine.

Lehnert, D. (1988). Vo-ag in Vicksburg: How local people revitalized and saved the program. The National Future Farmer, Vol.36(5), 18-20.

Leopold, A. (1960). A Sand Country Almanac New York, Oxford University Press.

Loomis, G. (1986). The latest developments and technology in soil and water conservation. The Agricultural Education Magazine Vol. 58(11), 17-18.

Lohr, S.L. (1999) Sampling: Design and Analysis. Brooks Cole Publishing Company. Pacific Grove California

Malpiedi B. (1989). Agriscience and Emerging Technologies. The Agricultural Education Magazine, Vol. 61(8), 4.

Marshall, M. (1996) Issues in Biotechnology Extension Education in Agricultural Biotechnologies: Issues and Choices National Agricultural Biotechnology Council (NABC) Publication.

Martin, R.A. (1987).Chairperson, Compiler 1987 Iowa Technical Committee on Biotechnology. Final Report. State Board of Vocational Education, Des Moines Iowa.

Martin, R.A. (1988). Biotechnology Enters Vocational Agriculture. Vocational Education Journal, Vol.62 (5): 36-38.

Mayer, W. V. and J.D. McInvervey (1984). Genetically Based Biological Technologies.

Biology and Human Welfare. Commission for Biological Education. Paris. UNESCO.

McCormick. F.G. and Cox. D.E. (1988). An assessment of instructional units for teaching Animal Nutrition Principles. Proceedings of the 66th Annual Western Region. Agricultural Research Seminar. Fort Collins Colorado. April 20-23. 1988.

Mckay. S. (Speaker). (1988). Emerging Technologies (Videocassette recording No.7) The National Conference on Agriscience and Emerging Technologies. Orlando. Florida. October 1988.

Mc'Neil. J. (1996). Curriculum: A Comprehensive Introduction. University of California. and Harper Collins College Publishers.

Moore. J.A. (1987). New wine in old bottles. The Agricultural Education Magazine. Vol. 60 (4). 5-6.

Moss. J. W. (1989). Agricultural education's' new era. growing more diverse, scientific and international. Vocational Education Journal Vol. 64 (4). 32-33.

National Academy of Sciences (1985). New Directions for Biosciences Research in Agriculture: High reward opportunities. (NRC. Report No.PD-147). Washington. D.C.: U.S. Printing Office.

National Commission of Pre-College education (1983). Guidelines for Curriculum Development in Sciences (NBS Rep. No L-015) Washington D.C. U.S. Department of Education.

Newman. M.E. and Johnson. D.M. (1994) Inservice education needs of teachers of pilot agriscience courses in Mississippi. Journal of Agricultural Education. Vol. 35 (1). 54- 60.

O'Neil. J. (1992) Preparing for the changing workplace. Educational Leadership. Vol. 49 (6). 6-9

Orr. D. (1992). Ecological Literacy: Education and Transition to a Postmodern World State

University of New York Press. Albany.

Orton, R. (1996). Teacher Beliefs and Student Learning http: www.ed.uiuic. edu/eps/pes-yearbook/96-docs/orton.html.

Osborne, E. W. and J.E. Dyer (2000). Attitudes of Illinois Agriscience Students and their Parents toward Agriculture and Agricultural Education Programs. Journal of Agricultural Education 41(3), 50-59.

O'Kelley (1985) Vocational education in agriculture and the career education movement. Journal of the American Association of Teacher Educators in Agriculture 17(1), 16-26

Perry S. (1989). One Past that's Prologue. Vocational Education Journal, Vol. 64(1), 31-33.

Pins, K. (1990). LISA: Love or Leave it behind. Des Moines Register, /Des Moines, Iowa pp. 1J – 2J

Progressive Farmer (1999). Biotech: Keep it Separate. Vol. 114 (9) 7

Rajasekeran, B. (1989). A National Study to Determine the Role of Biosciences / Biotechnology in Agricultural Education as Perceived by Vocational Agriculture Instructors. Master's thesis, Iowa State University.

Rao, A.N. and. Pritchard A.J (1984). Agriculture and Biology Teaching Science and Technology Education: Paris: UNESCO.

Roegge, C. A. and Russell, E.B. (1990). Teaching Applied Biology in Secondary Agriculture:Effects on Student Achievement and Attitudes: Journal of Agricultural Education, Vol. 31(1): 27-31.

Rogers, E.M. (1983). Diffusion of innovations. New York. The Free Press

Rolings. N.G. and Wagemaker, M.A.E. (Eds.) (1998). A new practice: facilitating sustainable agriculture. In Facilitating Sustainable Agriculture: Participatory Learning and Adaptive management in times of environmental uncertainty. Cambridge University

Press.

Rudd R.D. and Hillson, J.H. (1995) Teacher Characteristics related to the adoption of the agriscience curriculum in Virginia middle schools agricultural education programs. Journal of Agricultural Education 36 (2), 19-27

Schor, J. (1994). The Evolution and development of Biotechnology [microform] a revolutionary force in American agriculture. Microfiche [Washington, D.C.].

Smith, D. (1989). Toto I don't think we're in Kansas Anymore – Agricultural Education in a Land of Biotechnology, The Agricultural Education Magazine. Vol. 61(8), 8-11

Stanbury, D. and. Coulter, K.J (1986). Agriculture a World of Scientific and Professional Opportunities. Research for Tomorrow: 1986-Year Book of Agriculture. Washington, D.C. USDA

Stasz C. and Grubb, W.N. (1991). Integrating academic and vocational education: Guidelines for assessing a fuzzy reform. (Report No. MDS -375). Berkeley, CA: National Center for Research in Vocational Education.

Stasz, C. Kaganoff, T., & Eden, R.A. (1994). Integrating academic and vocational education: A review of literature, 1987-1992 Journal of Vocational Research, Vol. 19, 2 19-28

Steele, R. (1997) Analysis of the Continuing Decline in the Use of Supervised Agricultural Experience (SAE) in New York. Journal of Agricultural Education Vol. 38 (2), 49-58.

Swortzel, K. A. (1999) Current Status of Preservice Teacher Education Programs in Agriculture National Association of Colleges and Teachers of Agriculture (NACTA) Vol.43 (1), 37-42

Terry, R. Herring, D.R. and Larke, A. (1992) Assistance needed for elementary teachers in Texas to implement programs of agricultural literacy Journal of Agricultural Education, Vol. 33 (2) (51-60)

Thomas R. and Groves, L. (1986) Participation of Teachers in the Bioscience Program (NRC Report No.123) Washington, D.C.: U.S. Government Printing Office.

Thompson, G. W. and Balschewied, M.M. (1999). Attitudes of Oregon Agricultural Science and Technology Teachers Toward Integrating Science. Journal of Agricultural Education. Vol. 40 (3), 21-29.

Thompson, G.W. and Balschweid, M.M. (2000) Integrating science into agriculture programs: Implications for addressing state standards and teacher preparation programs Journal of Agricultural Education Vol.41 (2), 73-80.

Trexler, C. J. (2000). A Qualitative Study of Urban and Suburban Elementary Student Understanding of Pest related Science and Agricultural Education Benchmarks, Journal of Agricultural Education. Vol. 41 (3), 89-102.

Tyler, R.W. (1950) Basic Principles of Curriculum and Instruction Chicago: University of Chicago Press

Vold, L. (1988). The role of the Biosciences in the study of Agriculture as Perceived by Vocational Agriculture Teachers in Iowa, Master's thesis Iowa State University, Ames, Iowa.

Walters, R. (1997) Consumer Perspective National Agricultural Biotechnology Council (NABC) Report 9 Resource Management in Challenged Environments pp. 65-70.

Waters, R.G. & Haskell, L.J. (1989) Identifying staff development needs of cooperative extension faculty using a modified Borich needs assessment model. Journal of Agricultural Education 30 (2), 26 -32

Williams, D.L. and Pope J. (1989). Shaping agricultural education for the twenty-first Century. The Agricultural Magazine 61(8), 5-7.

Wilson, K. and Flowers, J. (2002) Factors influencing the intent of North Carolina agricultural educators to adopt agricultural biotechnology curriculum. Journal of Agricultural Education 43 (1), 69-78.

Wirth A.G. (1992) Education and Work for the Year 2000 Choices We Face. San Francisco CA. Jossey Bas Inc.

Wood, R.K.S. (1996). Sustainable agriculture: The role of plant pathology. Canadian Journal of Plant Pathology Vol.18:141-141.

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And finally, I am grateful to my children Connie, and Luke, for the inspiration to strive for a better and more caring world and for constantly reminding me what life is really about.

APPENDIX A. HUMAN SUBJECT APPROVAL FORM

OFFICE USE ONLY
EXPEDITED X FULL COMMITTEE____ ID# 01-345

PI Name: Theresa Sikinyi **Title of Project:** The Role of Biotechnology in Agricultural Education in Secondary Schools as Percieved by Agricultural Educators in the North Central Region of the USA

Checklist for Attachments

The following are attached (please check):

13. ☒ Letter or written statement to subjects indicating clearly:
 a) the purpose of the research
 b) the use of any identifier codes (names, #'s), how they will be used, and when they will be removed (see item 18)
 c) an estimate of time needed for participation in the research
 d) if applicable, the location of the research activity
 e) how you will ensure confidentiality
 f) in a longitudinal study, when and how you will contact subjects later
 g) that participation is voluntary; nonparticipation will not affect evaluations of the subject

14. ☐ A copy of the consent form (if applicable)

15. ☐ Letter of approval for research from cooperating organizations or institutions (if applicable)

16. ☒ Data-gathering instruments

17. Anticipated dates for contact with subjects:

First contact	Last contact
2/10/01	3/15/01
Month/Day/Year	Month/Day/Year

18. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:

12/31/01
Month/Day/Year

19. Signature of Departmental Executive Officer — Date — Department or Administrative Unit

Robert A. Martin — 1-16-01 — Department of Agricultural Education and Studies

20. Initial action by the Institutional Review Board (IRB):

☐ Project approved ________ Date ☐ Pending Further Review ________ Date ☐ Project not approved ________ Date

☐ No action required ________ Date

21. Follow-up action by the IRB:

Project approved ________ Date Project not approved ________ Date Project not resubmitted ________ Date

Patricia M. Keith — 1-24-01 — P M Keith
Name of IRB Chairperson — Date — Signature of IRB Chairperson

APPENDIX B. COVER LETTER AND QUESTIONNAIRE

Iowa State University
Department of Agricultural Education
201, Curtiss Hall
Ames, Iowa 50010

Dear Ag. Educator

The reform of the agricultural education curriculum that was started 12 years ago stressed the need for infusion of science into the agricultural education curriculum in the U.S.A. The applied agricultural sciences were considered to be the providers of the framework for job opportunities. Applied agricultural sciences particularly the field of biotechnology is still an area of expanding job opportunities. This study is being conducted as a follow up to the reform of the agricultural education curriculum. The study seeks to gather more information on what should be taught related to biotechnology in agriculture as perceived by agricultural educators in the North Central Region of the U.S.A. The results of this study will be used for a Ph.D program in Agricultural Education.

We hope that you as an educator can help us identify the important bioscience and biotechnology knowledge and skills and the degree to which instruction in these areas could and should be expanded. Your response to this questionnaire is essential for improving instructional materials in agricultural biotechnology that will help students by preparing them for job opportunities in the diverse agriculture industry. The questionnaire will take approximately 20 minutes to complete.

Your responses will be held in strict confidence and used for statistical purposes only. The code numbers assigned to questionnaires will be used to identify those who have not responded to the questionnaire. We are interested in group data only. All instruments will be destroyed after the data is collected. We would appreciate your help in this study. We feel that the information could assist us in developing higher quality programs of instruction in agriculture in the future

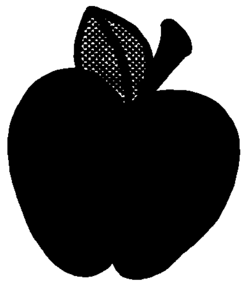
Thank you for your cooperation.

Sincerely.

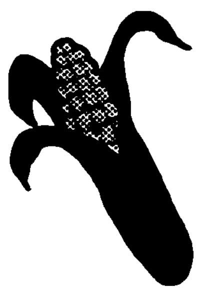
Robert A. Martin
Prof. & Head
Tel: 515-294-0896

Theresa Sikinyi
Research Assistant
Tel: 515-294-4349

The Role of the Biosciences and Biotechnology in



Agricultural Education in Secondary Schools as Perceived by Agricultural Educators in the North Central Region of the U.S.A



Iowa State University

PART I: Teacher perceptions regarding the infusion of biotechnology into the Agricultural Education curriculum

Directions: Please indicate, the extent to which you agree with the following statements as they relate to teaching about biotechnology in Agricultural Education.

Key
SD = Strongly Disagree
D = Disagree
N = Neutral
A = Agree
SA = Strongly Agree

Please Begin

1. Infusion of sciences basic to biotechnology is essential for agricultural education in secondary schools.	**SD**	**D**	**N**	**A**	**SA**
2. Learning basic sciences (Chemistry Biology, Physics and others) better understand agricultural sciences.	**SD**	**D**	**N**	**A**	**SA**
3. Students should learn how to explain the processes that occur in plants and animals while learning biotechnology.	**SD**	**D**	**N**	**A**	**SA**
4. Infusion of more science into the agricultural education curriculum would exposes students to diversified career opportunities in agriculture.	**SD**	**D**	**N**	**A**	**SA**
5. Learning about biotechnology helps students solve practical problems in agriculture.	**SD**	**D**	**N**	**A**	**SA**
6. Studying the sciences basic to agriculture helps students develop skills in related agriculture fields.	**SD**	**D**	**N**	**A**	**SA**

Note: SD= Strongly Disagree: D= Disagree; N= Neutral; A= Agree; SA = Strongly Agree

7. The infusion of biotechnology requires modification of the Agricultural Education curriculum.	SD	D	N	A	SA
8. The infusion of biotechnology requires more teacher in-service education.	SD	D	N	A	SA
9. The infusion of biotechnology increases student interest in studying Agricultural. Education.	SD	D	N	A	SA
10. Students are interested in learning the basic sciences as they are related to agriculture.	SD	D	N	A	SA
11. I am interested in relating basic science skills and knowledge to agriculture.	SD	D	N	A	SA
12. It takes additional time for the teachers to incorporate biotechnology into the study of agriculture.	SD	D	N	A	SA
13. Additional instructional materials are required for infusing biotechnology into the study of agriculture.	SD	D	N	A	SA
14. The infusion of biotechnology into the agriculture curriculum strengthens FFA.	SD	D	N	A	SA
15. The infusion of biotechnology into agriculture helps develop meaningful supervised agricultural experience programs.	SD	D	N	A	SA

PART II Competencies in Bioscience and Biotechnology

Directions: Listed below are some bioscience and biotechnology competencies that may be appropriate for instruction in agriculture.

A. Please indicate the extent to which the competencies should be infused into the agricultural education curriculum.

B. Indicate the extent to which you would be willing to expand instruction given needed materials and inservice training in Bioscience and Biotechnology.

Key
SD = Strongly Disagree
D= Disagree
N = Neutral
A = Agree
SA = Strongly Agree

Plant Science

Statement	A: Infusion of competency	B: Willingness to expand instruction given inservice education.
1. Conduct an experiment to demonstrate photosynthesis and respiration	SD D N A SA	SD D N A SA
2. Demonstrate the practice of hydroponics	SD D N A SA	SD D N A SA
3. Explain the importance of apical meristem in growth	SD D N A SA	SD D N A SA
4. Describe how nitrogen fixation takes place in leguminous crops	SD D N A SA	SD D N A SA
5. Demonstrate the effect of growth hormones on the rate of sprouting of vegetatively propagated plants	SD D N A SA	SD D N A SA

PLANT SCIENCE

Note: SD= Strongly disagree; D= Disagree; N= Neutral; A= Agree; SA = Strongly agree

Statement	A: Infusion of competency	B: Willingness to expand instruction given inservice education
6. Identify some plant growth regulators	SD D N A SA	SD D N A SA
7. Explain the process of transpiration	SD D N A SA	SD D N A SA
8. List the plant growth limiting factors	SD D N A SA	SD D N A SA
9. Demonstrate the selective action of herbicides	SD D N A SA	SD D N A SA

GENETICS

Note: SD = Strongly disagree; D = Disagree; N= Neutral; A = Agree; SA = Strongly Agree

Statement	A: Infusion of competency	B: Willingness to expand instruction given inservice education.
10. Distinguish between a plant and an animal cell	SD D N A SA	SD D N A SA
11. Describe the function of DNA	SD D N A SA	SD D N A SA
12. Describe the process of tissue culture	SD D N A SA	SD D N A SA
13. Describe the cloning of genes	SD D N A SA	SD D N A SA
14. Describe the different ways in which mutation takes place in plants	SD D N A SA	SD D N A SA
15. State Mendel's law of inheritance	SD D N A SA	SD D N A SA
16. Explain the process of gene insertion into germ cell lines	SD D N A SA	SD D N A SA

Note: **SD** = Strongly Disagree **D** = Disagree; **N** = Neutral; **A** = Agree; **SA** = Strongly Agree

Statements	A: Infusion of competency	B: Willingness to expand instruction given inservice education.
17. Describe the advantages of modern gene manipulation techniques	**SD D N A SA**	**SD D N A SA**
18. Explain the role of monoclonal antibodies in progeny testing	**SD D N A SA**	**SD D N A SA**
19. Explain the process of transgenesis	**SD D N A SA**	**SD D N A SA**
20. Describe the role of gene splicing in the production of bovine and porcine somatotrophin	**SD D N A SA**	**SD D N A SA**
21. Explain the process of embryo transfer	**SD D N A SA**	**SD D N A SA**
22. Describe gene expression	**SD D N A SA**	**SD D N A SA**

ANIMAL SCIENCES

Note: SD =Strongly disagree; **D** = Disagree; **N** = Neutral; **A** = Agree; **SA** = Strongly Agree

Statement	**A**: Infusion of competency	**B**: Willingness to expand instruction given inservice education.
23. Explain the role of bovine growth hormones in milk production	**SD D N A SA**	**SD D N A SA**
24. Explain the principle of immunization	**SD D N A SA**	**SD D N A SA**
25. Demonstrate the use of vaccines against major animal products	**SD D N A SA**	**SD D N A SA**
26. Explain the physiology of lactation, egg production and meat production in animals	**SD D N A SA**	**SD D N A SA**

MICROBIOLOGY:

Note: SD = Strongly disagree; **D**= Disagree; **N** = Neutral; **A** = Agree; **SA** = Strongly agree;

Statement	**A:** Infusion of competency	**B:** Willingness to expand instruction given inservice education
27. Describe the ways of classifying microorganisms related to agriculture	**SD D N A SA**	**SD D N A SA**
28. Distinguish the difference between fungi and bacteria	**SD D N A SA**	**SD D N A SA**
29. Draw the structure of a selected fungus in agriculture	**SD D N A SA**	**SD D N A SA**
30. Observe the structure of a bacterial cell under the microscope	**SD D N A SA**	**SD D N A SA**
31. Distinguish the difference between autotropic and heterotropic microbes	**SD D N A SA**	**SD D N A SA**
32. List beneficial microbes in agriculture	**SD D N A SA**	**SD D N A SA**
33. Demonstrate culturing of microorganisms in the laboratory	**SD D N A SA**	**SD D N A SA**
34. Identify nitrogen fixing organisms and explain how they fix nitrogen	**SD D N A SA**	**SD D N A SA**

FOOD SCIENCE

Note: SD = Strongly disagree; D= Disagree; N = Neutral; A = Agree; SA = Strongly agree;

Statement	**A:** Infusion of competency	**B:** Willingness to expand instruction given inservice education.
35. Describe the importance of yeast in agriculture for product enhancement	**SD D N A SA**	**SD D N A SA**
36. Identify the fungi that spoil fruits and vegetables	**SD D N A SA**	**SD D N A SA**
37. Explain the microbial activity in milk and how it helps in the formation of milk products	**SD D N A SA**	**SD D N A SA**
38. Describe the process of fermentation	**SD D N A SA**	**SD D N A SA**
40. Identify some artificial sweeteners that could be manufactured in the industry using biotechnology	**SD D N A SA**	**SD D N A SA**

SUSTAINABLE AGRICULTURE:

Note: SD = Strongly disagree; **D** = Disagree; N= Neutral; **A** = Agree **SA** = Strongly Agree

Statement	A: Infusion of Competency	B: Willingness to expand instruction given inservice
41. Explain the use of resistance in the management of diseases, insects and weeds	**SD D N A SA**	**SD D N A SA**
42. Explain the use of natural enemies in the management of insects, diseases and weeds	**SD D N A SA**	**SD D N A SA**
43. Describe the process of gene enhancement in the production of varieties suitable for specific environments	**SD D N A SA**	**SD D N A SA**
44. Explain the biological properties of soil	**SD D N A SA**	**SD D N A SA**
45. Describe the importance of soil organic matter	**SD D N A SA**	**SD D N A SA**

ENVIRONMENTAL EDUCATION

Note: SD = Strongly disagree; **D** = Disagree; N= Neutral; **A** = Agree **SA** = Strongly Agree

Statement	A: Infusion of Competency	B: Willingness to expand instruction given inservice education.
46. Explain the use of micro-organisms in degrading wastes in the environment	**SD D N A SA**	**SD D N A SA**
47. Describe the relationship between plants animals and micro-organisms within a particular ecosystem	**SD D N A SA**	**SD D N A SA**
48. Explain the enzymatic activity of bacteria in the decomposition of crop residues	**SD D N A SA**	**SD D N A SA**

PART III. DEMOGRAHIC DATA

Directions: Please respond to the following questions by checking the appropriate answers or filling in the blank to describe your characteristics.

1. How many years of experience do you have in teaching agriculture?

   ________ **NUMBER OF YEARS**

2. What level of education have you attained?

   ________ **BS**

   ________ **MS**

   ________ **PH.D**

3. How many students are enrolled in your agriculture program?

   ________ **NUMBER OF STUDENTS**

4. Have you received any pre-service training in biotechnology?

   ________ **YES**
   ________ **NO**

5. Have you participated in any in-service training programs in? biotechnology?

   ________ **YES**
   ________ **NO**

6. What is your gender?

   ________ **MALE**

   ________ **FEMALE**

7. What is your age?

   ________ **YEARS**

8. Comments

Code NO: ____________

THANK YOU FOR YOUR COOPERATION

Please return to: Dr Robert Martin
Professor and Head
Department of Agricultural Education
and Studies
201 Curtiss Hall
Iowa State University
Ames, IA 50011

APPENDIX C. FOLLOW -UP LETTER

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Department of Agricultural Education and Studies
201 Curtiss Hall
Ames, Iowa 50011-1050
Administration and Graduate Programs 515 [illegible]
Research and Extension Programs 515 [illegible]
Undergraduate Programs 515 294-0024

DATE: May 4, 2001

TO: Participants in Research on Biosciences/Biotechnology

RE: Bioscience and Biotechnology Survey

Dear Sir/Madam:

A few weeks ago you were sent a questionnaire regarding the teaching of bioscience in agricultural education. Many people have returned their questionnaire and we sincerely appreciate that. However, there are some who have not yet returned the survey questionnaire as of this date. We understand that this is a busy time for you, but we would appreciate your response to the survey. For the study to be successful we need your input.

If you have already returned the questionnaire, please disregard this letter. If you have not returned the questionnaire may we please hear from you soon? Thank you for your cooperation.

Sincerely,

Dr. Robert Martin
Professor & Head

Theresa Sikinyi
Research Assistant

caa

APPENDIX D. ADDITIONAL TABLES

Table 42. Means, standard deviations and F-values on areas of competency perceived to be important by agricultural educators in the North Central Region with or without preservice training

Competencies	Preservice (n= 164)		No Pre-service (n=157)		F-value
	Mean	S.D.	Mean	S.D.	
Competencies in Plant Science (9 items)	4.18	0.48	4.11	0.43	1.71
Competencies in Genetics (13 items)	3.98	0.58	3.93	0.53	0.75
Competencies in Animal Science (4 items)	4.19	0.53	4.14	0.59	0.63
Competencies in Microbiology (8 items)	3.86	0.60	3.82	0.62	0.37
Competencies in Food Sciences (5 items)	3.97	0.63	3.92	0.62	0.42
Competencies in Sustainable Agriculture (5 items)	4.21	0.52	4.19	0.54	0.18
Competencies in Environmental Education (3 items)	4.10	0.70	4.02	0.65	0.94

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. [b] Equal variances assumed.
* $p \leq 0.05$

Table 43. Means, standard deviations and F-values on areas of competency perceived to be important by agricultural educators in the North Central region with or without inservice training.

Competencies	In-service Training (n= 198)		No In-service Training (n=122)		F- value
	Mean	S.D.	Mean	S.D.	
Competencies in Plant Science (9 items)	4.17	0.48	4.09	0.43	2.19
Competencies in Genetics (13 items)	3.99	0.56	3.89	0.54	2.32
Competencies in Animal Science (4 items)	4.20	0.52	4.10	0.60	2.20
Competencies in Microbiology (8 items)	3.85	0.60	3.82	0.62	0.18
Competencies in Food Science (5 items)	3.96	0.64	3.90	0.61	0.87
Competencies in Sustainable Agriculture (5 items)	4.21	0.53	4.18	0.52	0.36
Competencies in Environmental Education (3 items)	4.11	0.69	3.97	0.65	3.63

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. [b] Equal variances assumed.
* $p \leq 0.05$

Table 44. Means and standard deviations of composite competencies for willingness to expand the seven areas of competencies.

Competency Area	Composite means [a]	S.D.
Sustainable Agriculture	4.19	0.59
Animal Science	4.16	0.58
Plant Science	4.13	0.52
Environmental Education	4.06	1.07
Genetics	3.94	0.59
Food Science	3.94	0.65
Microbiology	3.84	0.64

[a] 1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D. = Standard deviation

Table 45. Means, standard deviation, on overall perceptions regarding biosciences /biotechnology held by agricultural educators in the North Central Region for each state (N=325)

State	Number of Respondents	Mean	Standard Deviation
Illinois	42	4.00	0.44
Indiana	32	3.97	0.37
Iowa	43	3.94	0.42
Kansas	17	3.96	0.26
Michigan	16	3.98	0.32
Minnesota	19	4.06	0.45
Missouri	34	3.92	0.34
Nebraska	18	4.05	0.47
North Dakota	12	4.11	0.34
Ohio	44	4.09	0.38
South Dakota	13	4.08	0.53
Wisconsin	35	4.18	0.36
Overall Mean	325	4.02	0.40

1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D. = Standard deviation.

Table 46. Means, standard deviations and F-value for competencies considered necessary for plant sciences based on whether the agricultural educators have or did not have some inservice training

Competencies	Inservice Training (n=200)		No Inservice Training (n=123)		F-value
	Means[a]	S.D.	Means[a]	S.D.	
Conduct an experiment to demonstrate photosynthesis	4.24	0.67	4.14	0.67	1.82
Demonstrate the practice of hydroponics	4.19	0.70	4.01	0.73	4.53*
Explain the importance of apical meristem in growth	3.96	0.75	3.80	0.76	2.89
Describe how nitrogen fixation takes place in leguminous crops	4.25	0.60	4.06	0.67	6.11*
Demonstrate the effect of growth hormones on the rate of sprouting of vegetatively propagated plants	4.20	0.68	4.10	0.57	1.88
Identify some plant regulators	4.09	0.63	4.03	0.56	0.71
Explain the process of transpiration	4.20	0.61	4.24	0.47	0.43
List the plant growth limiting factors	4.25	0.58	4.27	0.48	0.14
Demonstrate the selective action of herbicides	4.16	0.68	4.18	0.64	0.05

[a]1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D.= Standard deviation.
* $p \leq 0.05$.

Table 47. Means, standard deviations and F-values of competencies considered necessary for genetics by agricultural educators based on inservice training.

Competencies	In-service Training [a] (n=200)		No In-service Training [a] (n=123)		F-value
	Means	S.D.	Means	S.D.	
Distinguish between a plant and an animal cell	4.12	0.72	4.15	0.67	0.72
Describe the process of tissue culture	4.21	0.66	4.12	0.76	1.10
Describe the process of tissue culture	4.08	0.72	4.05	0.75	0.19
Describe the cloning of genes	4.04	0.80	4.00	0.82	0.25
Describe the different ways in which mutation takes place in plants	3.96	0.72	3.92	0.71	0.22
State Mendel's law of inheritance	4.14	0.71	3.97	0.75	4.21*
Explain the process of gene insertion into germ cell lines	3.84	0.83	3.72	0.88	1.40
Describe the advantages of modern gene manipulation techniques	3.97	0.81	3.87	0.85	1.05
Explain the role of monoclonal antibodies in progeny testing	3.56	0.86	3.56	0.81	0.01
Explain the process of transgensis	3.66	0.87	3.53	0.81	1.53
Explain the process of embryo transfer	4.27	0.68	4.07	0.66	6.27*
Describe the role of gene splicing in the production of bovine and porcine somatrophin	3.77	0.89	3.61	0.87	2.12

[a]1=Strongly disagree. 2=Disagree. 3=Neutral. 4=Agree. 5= Strongly agree. S.D. = Standard deviation.
* $p \leq 0.05$

APPENDIX E. OPEN COMMENTS

Open Comments from the Participants

Illinois

1. Agricultural education needs to teach skills that will enable the family farm to continue not just preach the sermon of bigger is better.
2. We have had an aquaculture system, incubator, and microscopes and have just built a 30 X 60 greenhouse. All are used in agriscience to teach biotechnology. My daughter has accepted a position as a graduate assistant at the University of Illinois at Urbana in ACES and knows the importance of biotechnology plus careers available.
3. Biotechnology is new and needs to be added where students are interested – such as agriscience / general science course. But it should not replace existing subject areas it should enhance what is already taught.
4. Please send surveys at better times in the future, like mid-fall.
5. Our demographic area does not demand our agriculture preparation to concentrate on biotechnology.
6. I strongly support the suggested infusion to better qualify our students for the vast knowledge required to be more productive in research and compete in the agricultural industry.
7. These are important topics, time and inservice is the key.
8. The science concept is OK but I think the science can get too high tech and more into the science department vs. the agricultural department. My department lacks equipment and proper facilities to do most of what you listed on the survey.
9. More biotechnology is a good thing. It takes more training and more facilities and equipment than most agriculture departments have.
10. More inservice is needed in biotechnology, but it must be high school classroom realistic. The best inservice programs are the ones taught by other high school teachers, with hands on activities/ labs.

11. I have put in place several of these principles in my agriscience classes.

12. I would love to study more about biotechnology then I could give you a better survey.

Indiana

1. I would like a copy of the findings of this study.
2. There is a definite need for more inservice on this topic as the changes occur so quickly that it is hard to keep up with all of them.
3. Agriculture education needs more science and less 100% FFA. Why not have a state level agriculture competency test to compare programs and techniques?
4. The real question is what do I teach? What do I teach, if I only have 4 classes per year for secondary school agriculture students? What topics serve the most opportunity? What would a survey of high school students tell us about why they are taking agriculture? Is it a specific topic or general Ag /FFA skills? This may be different for different states, but I'll bet a lot would be leadership teamwork responsibility, creativity, communications etc. Is this what general employees really want? If so, what class or program will provide those experiences and opportunities. Agriculture and FFA is the mortar that fills in the spaces around the education binds of Math, English, Science etc. What type of classes provide this? More academic students may take a "Leadership management – current events class". We don't prepare enough for them to go into agriculture careers right after high school and many don't want agriculture careers but still want FFA and Ag. I got lost and interrupted on the survey several times –sorry.
5. I think it is necessary for Ag-Educators to be willing to change our curriculum to better serve the changing agriculture industry if we are going to be of any help to our students.
6. I teach mainly animal science so that is why this is of main interest.
7. I think it is going to be important to teach low levels of biotechnology in our classrooms especially the classes that count for science credit. As a new teacher, I feel it is important not only to provide teachers with information but also provide the opportunity for us to

obtain materials for us to use in the classroom and instruction on best ways to teach it at lower levels. I hope this is going to be a new trend in agricultural education.

8. Would like to incorporate more biotechnology, but most of my students couldn't handle it. They have failed biology for more times and so on.
9. Thanks.
10. Agriscience teachers need all the help they can get when it comes to hands-on activities to help explain, show, demonstrate or give actual examples of any and all activities.
11. There are a lot of agriculture teachers that teach agriculture classes that are also available for science credit, and in order for us to do that, we have to make the class more scientific. By making the classes more scientific, we bring more hands-on activities into the classroom.
12. We need to infuse science into agriculture programs. However, we need to be properly trained and provided in-service. A lot of good functional laboratories are available, but we need the resources to help teach this new and very useful material.
13. 48% of agriculture students are in mechanics.
    31% agriculture. Students are in horticulture.
    13% of agriculture. Students are in production.
    8% of agriculture. Students are in SAE.

Iowa

1. Is there any interest in a state agricultural education curriculum for Iowa?
2. Success of adding bioscience and biotechnology into the curriculum will depend on whether students can use the course for science credit.
3. A lot of ideas and concepts that I would need help with before infusing them into my classes. But, many of them of them sound interesting and worth working on.
4. I am not in favor of lots of standards. I do want to learn new information, but I do not want to be told what I need to teach.

5. It takes time, money and materials to teach more biotech. We are already inundated with all sorts of curriculum materials topics and etc.
6. I agree with most information on science and biotechnology. These classes are required to be set up on a semester basis! I have trouble getting things connected now. I have 7 preparations now; help! How do you get it all done? New tech? Yes! Added value? Yes! Adapt to the needs of the times? Yes! How does one person, departments handle it all? (and on teachers salary basic of 19,400! ----- Iowa may lose more than its' young people!) don't forget that there are so many of these that we do not touch on. We must, however, keep up with new methods and information ----pros and con.
7. We must be committed to staying well informed of all the new technologies. We should lead and not follow.
8. I have attended biotechnology workshops but have used very little in the classroom. I feel uncomfortable – unsure of what I do. ISU helps enormously with any project.
9. I strongly believe that science and agriculture go hand in hand. Agriculture teachers need more training on how to promote agriculture as a science not only as a vocational subject.

Kansas

1. I agree that biosciences /biotechnology needs to be taught but in order to teach it properly one needs a lab. There is no way our school will spend the money to maintain a lab. So I teach what awareness I can. I have taught for eight years and I finally have gotten books for each subject taught. It took eight years!
2. I am certified in 3 areas of science so I am able to offer agriscience courses for science credit toward graduation. I am currently attempting to get my agriculture- biology course approved for a science course needed for attending our state universities. I incorporate many aspects of biotechnology in my class, but not nearly as in depth as some of these survey questions seem to indicate.

3. I believe that being a younger teacher. I am more willing to infuse sciences into my curriculum. Many of the competencies you have listed are things that are already in the curriculum that I teach.
4. Our program has a slight science / biotechnology emphasis but our particular program and community wants production and basics of agriculture Industry.

Michigan

1. I already incorporate most of these things in my curriculum. It is good to continue to have inservice training in these areas. Things change.

Minnesota

1. I think all these topics would be great to teach, if they fit your program. Certainly you can't do them all and you would have to modify them for some students.
2. I view high school agriculture as an exploratory program to interest students in various areas of agriculture. I do not see high school agriculture as the training area for scientists or molecular biologists. I cover most of these areas very slightly.
3. This is a very good area of introduction and will be become more so in the future
4. Excellent survey. Hope it promotes the need for greater understanding of the role of biotechnology.
5. We are having a broader range of students enter our programs. They are not just the agriculture production stereotype. In addition, the science of agriculture is becoming more and more complex as research is changing the way we produce and manufacture. With the introduction of science concepts in my classes my students have demonstrated a better understanding of the world where they live and work. They are less fearful of change and are able to analyze a question they are faced with such as "Are genetically modified foods safe?"
6. I would be interested in inservice training if available in the summer or through distance learning. Thanks!

I would be very interested in receiving follow up information and any survey information that you are able to release. Thank you

Missouri

1. We definitely need quality training in biotechnology
2. Everything you mentioned could be taught in the agriculture classroom. However, time and resources tend to be the limiting factor.
3. What do I take out when all this is added? Perhaps leadership activities and parliamentary procedure. Good luck with your work.
4. We need better lab experiments that don't duplicate what has been done and at the elementary level. They need to challenge the students. In our quest to incorporate more scientific principles, we must be careful not to insinuate that science departments are not doing their jobs.
5. To institute these types of learning activities will require a significant investment in Agriculture departments that even our science department will be envious.
6. Business management other than production management has also been neglected in the agriculture curriculum over the years. Analysis of business strong and weak points financially needs to be added to the agriculture business curriculum.
7. Good Luck! Please send any other information that will help me out during my first year teaching. Thank you.

Nebraska

1. Not sure of # 25, if it is animal diseases I would strongly agree (SA) on both products.
2. Iowa is ahead of Nebraska in biotechnology training (As told by Iowa agriculture. teachers at the Pioneer workshop and summit 2000). Please inform on cooperation with UNL agricultural ed department inservice possibly in Iowa open to Nebraska agricultural instructors.
3. I don't think that we need to teach over again what they have learned in other curricula

areas. Review – yes, but not teach again.

North Dakota

1. Why explain, list, define, identify and describe? Why not experience, conduct research experiment?
2. I think incorporating new agriculture technologies are great, but let us remember good traditions that are time proven. Also, remember that teachers have limited time to learn new techniques and then incorporate them into the curriculum.
3. Any biotechnology inservice programs would be helpful and very useful.

Ohio

1. Have received pre-service training in biotechnology from industry.
2. Good Luck.
3. I think we need to look at the whole picture and not just quick fixes. We can't just genetically create or alter things without looking into long term results. I cannot believe people are not teaching most of what is on the survey.
4. I would like to involve more sciences and biotechnology in my curriculum but costs of various items are a real deterrent.
5. I need to have an easy to use and understand information on biotechnology for students and teachers to learn and present. Some areas of the country will be more able to use and incorporate than others. Money may be a problem. Limitations of teaching some of these competencies include finances, laboratory facilities and time.
6. We try to incorporate many of these science ideas as supplemental to main courses (science credits) the other time is spent on vocational hands on life learning endeavors.
7. It is all important, but time would limit how much depth a teacher would try to develop.

8. Our students are interested in hands-on shop work. Biotechnology is above their level of academic comprehension, causing them to lose interest (very few college prep kids). I don't have enough time or resources to properly prepare and teach what I teach now. This would be even more taxing. These are good subjects for advanced level work in high school or even collegiate level.
9. I filled this out because it has been submitted to me twice. We do not have agriculture program here but invest in one in the future. I really did not feel qualified to answer the questions but did so as honestly as I could.
10. I am in favor of incorporating biotechnology into my curriculum but I also need lots of inservice and teaching aids.
11. Not enough depth in the animal science category. You needed to survey teacher responses in more depth in the animal science area. It is highly ignored.
12. Many of these competencies are part of my curriculum already.

South Dakota

1. Although I have had small units on this topic, I would like to see a lot more of it to bring to the classroom and use it with students.
2. I may be a very typical responder, as I am an early adopter. I have been teaching a full year course in biotechnology since 1992. I have attended or taught numerous biotech workshops as well as graduate courses and also served on the U.S.D.E.'s biotechnology skills, standards project.
3. We definitely need more inservice training in ag-biotechnology. Many of us didn't have the opportunity for previous training in biotechnology as we were out of college well before they incorporated the material in the college curriculum.

Wisconsin

1. I would like to incorporate more of these concepts into my curriculum as I do have a number of them already. Time to incorporate and good sources of information are a must.

2. I feel an application of the basic sciences is important, not teaching basic sciences purely for the sake of basic sciences. For example, the difference between a plant cell and an animal cell needs to be taught in the context of why this concept is important in agriculture.
3. Adding these competencies to our agricultural education curriculum would, in my opinion, greatly enhance the quality of our instruction. We have a unique opportunity to introduce students to biotechnology in a non-biased non-commercial setting.
4. Most of these competencies I already teach but they are not recognized as part of our science curriculum.
5. Good Luck.
6. We have incorporated a fair amount of biotechnology/ sciences in our coursework already. My partner in teaching Ag.Ed here is also a biology teacher.
7. In terms of program success, I have observed that high school students are eager to enroll in programs using emerging technology. Even though I am nearing retirement, I would be interested in incorporating these concepts to strengthen our program.
8. After graduating from college I taught high school agriculture for three years. Then I was in the livestock feed business for 39 years. I then retired and I teach one class of agriculture five days a week for the past three years.
9. I currently team-teach a course in biotechnology with a science teacher. I also infuse some of the related information into my courses in veterinary science, crops for profit, plants for fun is profit, environmental research management.
10. You are assuming all teachers need additional training. That is incorrect.
11. In order to make the agriculture curriculum meet the demand for knowledgeable and skilled workers in industry, we as educators, need to keep up to date and informed of the scientific changes. We, in turn, must infuse these concepts and scientific principles into

our curricula. We need to change the face of agriculture as society and the industry change in order to compete in public education.

12. Having taught biotechnology as a class, I've had the opportunity to learn and use a great deal of material. However, it is hard to infuse great quantities of biotechnology in an already full curriculum, plus the average Ag.Ed. college student will get very little pre-service training in biotechnology.